



(11) **EP 0 788 282 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
20.01.2010 Bulletin 2010/03

(51) Int Cl.:
H04N 9/804 ^(2006.01) **H04N 7/52** ^(2006.01)
H04N 7/32 ^(2006.01)

(21) Application number: **97101782.7**

(22) Date of filing: **05.02.1997**

(54) **Quantization method**

Quantisierungsverfahren

Methode de numérisation

(84) Designated Contracting States:
GB NL

(30) Priority: **05.02.1996 JP 1854596**
02.04.1996 JP 7979596
03.06.1996 JP 13987196

(43) Date of publication of application:
06.08.1997 Bulletin 1997/32

(60) Divisional application:
06008271.6 / 1 711 015

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Description

FILED OF THE INVENTION

[0001] The present invention relates to an image coding apparatus for compressing and recording image data from video signals by coding, and an image decoding apparatus for regenerating the coded and recorded image.

BACKGROUND OF THE INVENTION

[0002] Recently there have been developed various video signal recorder that code and compress video signals of digital data by a specified mode and perform a digital recording. It is, however, required much expenses and labor for the standardization of compression modes and compressed algorithm hardware, e.g., LSI. In order to reduce the development costs for early development, it is preferable to apply a known standard and its corresponding accumulated techniques, a known hardware of compressed algorithms and the like. Hence there have been developed novel video signal recorders depending on the purpose.

[0003] When obtaining digital data to be treated by computers and the like, based on the video signal of such as TV signal, it is general that image data comprising digitized video signal is first obtained, the image data is then compressed and coded, and the obtained data is recorded or transmitted. The digitized image data is in a sequence of pixel data having pixel values indicating luminance and chrominance, and the image data is coded by processing to obtain coded image data.

[0004] As a general method for compressing/coding image data based on video signal, there is predictive coding. The predictive coding is a system in which a predictive value for an input pixel that is the object of coding is generated, and a difference value between the input pixel and the predictive value is subjected to non-linear quantization, the obtained data is then transmitted. When the image from video signal is treated, a predictive value is obtained by predicting a pixel value at a certain point, from its periphery pixels, based on that adjacent parts tends to have the same or an approximate pixel value indicating luminance and chrominance. The predictive coding has the advantages that the circuit scale for an apparatus is small and the compression rate is low. When data rate after compression is high, high-quality image is obtainable. This is the reason why the predictive coding has been widely used.

[0005] Figure 43 is a conceptual diagram explaining the linear processing and non-linear processing in quantization. Input data has a certain dynamic range. That is, the input data is represented in the range of d-bit as a dynamic range, and, the linear processing is possible. When n-bit output data is obtained by quantizing the input data, a suitable number of quantization representative values are selected, and quantizing values are allocated

to the representative values. To each input data, there is given a quantizing value allocated to a quantization representative value that is approximate to the input data. By setting the number of the quantization representative values to not more than 2^n , the output data can be treated by n-bit.

[0006] As shown in Figure 43, to set quantization representative values at uniform intervals is linear quantization. When an expected value is previously obtained as in the predictive coding, non-linear quantization in which the quantisation representative values are set densely in the vicinity of the expected value, and widely as the distance from the expected value is increased.

[0007] In Figure 43, there is shown a rounding processing of from 3-bit to 2-bit. By setting four (2^2) quantization representative values against eight (2^3) ones, the output data can be represented by 2-bit.

[0008] In the linear processing, the quantizing representative values are set, for example, by selecting every other piece, to assign the quantizing value. For input data having the values from 0 to 7, they are replaced with the adjacent quantizing representative value to give a quantizing value assigned to the respective representative value in the following manner. For the value of 0 or 1, its quantizing representative value is 0, for the value of 2 or 3, its quantizing value is 2, and the like.

[0009] In the non-linear processing, when an expected value for the input data is 3, for example, the setting of quantizing values will be set densely in the vicinity of 3, and roughly as the distance from 3 is increased. As the quantizing width is creased, that is, as the interval of the quantizing representative values is increased, the number of data replaceable with the quantizing representative value is increased. This shows that data of different value tends to be treated equally. Therefore, nearer the vicinity of the expected value, the magnitude of the quantizing value reflects more precisely the magnitude of the input value.

[0010] The non-linear quantization utilized in the predictive coding is performed in various systems. Since it is normally difficult to perform the non-linear quantization by such a simple operation as in the linear quantization, that is performed by referring to a table such as a ROM table. This might increase the circuit scale and the processing costs, resulting in the cost increase and the reduced processing speed.

[0011] On the other hand, the predictive coding has the problem that transmitted data is a difference value between an input value and a predictive value and, when an error of the predictive value occurs, such an error will be propagated at the regeneration. Thus in order to suppress such an error propagation within a certain range, there has been employed a method of inserting a PCM value periodically. This method, however, decreases the compression rate and causes the unevenness in image quality, failing to solve the problem.

[0012] A method of preventing the error propagation without reduction in compression rate is disclosed, for

example, in Japanese Patent Application No. 60-160599. In this method, among a plurality of non-linear quantizing units there is selected one unit whose quantization width in the vicinity of a predictive value is small, to perform the quantization. This method basically utilizes the direct quantization of input pixel values, not the quantization of differences. As a result, the predictive value error is hardly propagated. However, the construction provided with a plurality of quantizing units will increase its circuit scale, leading to the cost increase.

SUMMARY OF THE INVENTION

[0013] It is an object of the invention to provide a image coding apparatus that performs non-linear quantization processing at high speed and with a small circuit scale, without ROM tables, and prevents the error propagation during predictive coding without reduction in compression rate.

[0014] It is yet another object of the invention to provide a image decoding apparatus that performs decoding processing at high speed and with a small circuit scale, without ROM table.

[0015] Other objects and advantages of the present invention will become apparent from the detailed description given hereinafter; it should be understood, however, that the detailed description and specific embodiment are given by way of illustration only, since various changes and modifications within the scope of the invention will become apparent to the those skilled in the art from this detailed description.

[0016] According to the invention there is provided an image coding apparatus according to claim 1.

[0017] According to another aspect the invention provides an image decoding apparatus according to claim 10.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Figure 16 is a block diagram showing a construction of a image coding apparatus of Embodiment 15 of the invention.

Figures 17(a) to 17(d) are diagrams for explaining the quantization of the image coding apparatus of Embodiment 15.

Figure 18 is a block diagram showing a construction of the image decoding apparatus of Embodiment 15. Figure 19 is a block diagram showing a construction of an image coding apparatus of Embodiment 16 of the invention.

Figures 20(a) to 20(d) are diagrams for explaining the quantization of the image coding apparatus of Embodiment 16.

Figure 21 is a block diagram showing a construction of an image decoding apparatus of Embodiment 16. Figure 22 is a block diagram showing a construction

of an image coding apparatus of Embodiment 17 of the invention.

Figures 23(a) to 23(d) are diagrams for explaining the quantization of the image coding apparatus of Embodiment 17.

Figure 24 is a flow chart showing a coding algorithm of the image coding apparatus of Embodiment 17.

Figure 25 is a block diagram showing a construction of an image decoding apparatus of Embodiment 17. Figure 26 is a flow chart showing a decoding algorithm of the image decoding apparatus of Embodiment 17.

Figure 27 is a block diagram showing a construction of an image coding apparatus of Embodiment 18 of the invention.

Figure 28 is a flow chart showing a coding algorithm of the image coding apparatus of Embodiment 18.

Figure 29 is a block diagram showing a construction of an image decoding apparatus of Embodiment 18. Figure 30 is a flow chart showing a decoding algorithm of the image decoding apparatus of Embodiment 18.

Figure 31 is a block diagram showing a construction of an image coding apparatus of Embodiment 19 of the invention.

Figure 32(a) to 32(d) are diagram for explaining the quantization of the image coding apparatus of Embodiment 19.

Figure 33 is a block diagram showing a construction of an image decoding apparatus of Embodiment 19.

Figure 34 is a block diagram showing a construction of an image coding apparatus of Embodiment 20 of the invention.

Figure 35 is a block diagram showing a construction of an image decoding apparatus of Embodiment 20. Figure 36(a) and 36(b) are diagrams for explaining the coding of the image coding apparatus and the decoding of the image decoding apparatus of Embodiment 20.

Figure 37 is a block diagram showing a construction of an image coding apparatus of Embodiment 21 of the invention.

Figure 38 is a block diagram showing a construction of an image coding apparatus of Embodiment 22 of the invention.

Figure 39 is a flow chart showing a coding algorithm of an image coding apparatus of Embodiment 23 of the invention.

Figure 40 is a block diagram showing a construction of an image decoding apparatus of Embodiment 24 of the invention.

Figure 41 is a block diagram showing a construction of an error code processing unit of the image decoding apparatus of Embodiment 24.

Figure 42 is a block diagram showing a construction of a circuit shared between an image coding apparatus and an image decoding apparatus of Embodiment 25 of the invention.

Figure 43 is a diagram for explaining a non-linear quantization processing of a conventional image coding apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Embodiment 15

[0019] An image coding apparatus and an image decoding apparatus of Embodiment 15 are those in which a quantization representative point is added to a linear quantizing unit having a linear quantization representative value to realize a non-linear quantization unit performing quantization or reverse quantization.

[0020] Referring to Figure 16, there is shown the construction of the image coding apparatus of Embodiment 15. A pixel value input unit 101 inputs a pixel value having a dynamic range of d-bit. A linear quantization unit generator 102 generates a linear quantization unit having linear quantization representative points. A non-linear quantization unit generator 103 adds the quantization representative point to the vicinity of a predictive value to generate a non-linear quantization unit whose quantization width in the vicinity of the predictive value is smaller than that of the linear quantization unit. A quantization unit 104 quantizes an input pixel value using the non-linear quantization unit to obtain the quantization value of n-bit. An output unit 105 outputs the quantization value obtained in the quantization unit. A predictive value generator 106 generates a predictive value for the input pixel value from the peripheral pixels of the input pixel.

[0021] The operation of the image coding apparatus so constructed will be described. For shortness' sake, assuming that the input pixel value is indicated by 8-bit (d) and the quantization value after being coded is 6-bit (n) wherein $n=6$, $k=d-n=2$; and that in order to add quantization representative points, the upper limit number of the addition (m) is 5, which number is previously set.

[0022] In the predictive value generator 106, utilizing the peripheral pixels of the input pixel, a predictive value of 8-bit is generated for the pixel value from the pixel value input unit 101, as a linear sum obtainable from the quantization value of the peripheral pixels. Based on the predictive value thus generated, a quantization representative value for the input pixel value is set in the linear quantization unit generator 102 and the non-linear quantization unit generator 103.

[0023] Referring to Figures 17(a) to 17(d), there is shown an example of setting of quantization representative values, in which the predictive value is assumed to be 13.

[0024] The linear quantization unit generator 102 sets linear quantization representative values including the predictive value of 13 as a quantization representative value. The generator 102 is assumed to generate 2^n -m linear quantization representative values with quantization width of 2^k , wherein m is previously set as an upper

bound value of the quantization representative point to be added in the preceding processing. In this example, the quantization representative values are set with the quantization width of 4 (2^2), positioning the predictive value 13 in the center. As shown in Figure 17(a), 1, 5, 9 and 17, 21, 25, 29 are set near 13 in the shown range. The number of the quantization representative values set on the whole is 59 (2^6-5) from the above setting (2^n-m).

[0025] The non-linear quantization unit generator 103 adds not more than m quantization representative points near the above predictive value to reduce the quantization width near the predictive value than that of the linear quantization unit generator. In this example, 4 ($4 < m=5$) quantization representative values are added in the range of two levels around the predictive value of 13. As a result, the quantization width is set to 1 only around the predictive value. Other parts are set to 4 as described. The number of the resulting quantization representative values sums up to 63 ($< 2^6$), whereby the quantization value after coding is indicated in 6-bit.

[0026] Subsequently the quantization value for the smallest quantization representative value is set to be -31, and the quantization value is allocated in order of ascending, from the smallest quantization representative value. As shown in Figure 17(c), the quantization value of -2 is allocated to the quantization representative value of 1, ..., and 9 is allocated to 29 in this manner. On the whole, the quantization values of -31 to 31 are allocated in order of ascending.

[0027] The quantization unit 104 selects the nearest quantization representative value for an input pixel value to obtain its quantization value, and outputs it to the output unit 105. As shown in Figure 17(d), when a pixel value is 2, the quantization value is -2, when a pixel value is 14, the quantization value is 14, and the like.

[0028] As described above, in the image coding apparatus of Embodiment 15, the quantization representative values are set basically by the linear quantization processing, and the quantization representative values are added only in the vicinity of a predictive value. Therefore in the quantization processing there can perform such an operation processing as employed in linear processing. Even non-linear quantization does not require ROM table and the like. In stead of processing the difference between an input pixel value and a predictive value, the input pixel value is directly quantized, and therefore, the quantization representative value (pixel value) is proportional to the quantization value. Thus, since each quantization value itself contains the absolute level information, even when a predictive value is incorrect, error propagation is hardly caused. In the example illustrated in Figures 17(a) to 17(d), only four quantization representative values added to the vicinity of the predictive value, i.e., non-linear parts, are affected.

[0029] Referring to Figure 18, there is shown a construction of the image decoding apparatus of Embodiment 15. A description will be given of the operation when this apparatus decodes the data coded as described

above.

[0030] A quantization value input unit 301 inputs a quantization value as the result of coding. A reverse quantization unit 302 performs the reverse quantization of an input quantization value utilizing the non-linear quantization unit generated in the non-linear quantization unit generator 103. An output unit 303 outputs the result of decoding. Others are common to the image coding apparatus.

[0031] The operation of the image decoding apparatus so constructed will be described. When a quantization value as the result of coding is input from the input unit 301, a predictive value generator 106 generates, as a linear sum, a predictive value for the quantization value by utilizing the peripheral pixels of the input quantization value.

[0032] Similar to the image coding apparatus, based on the predictive value generated in the predictive value generator 106, a non-linear quantization unit whose quantization width is small only in the vicinity of the predictive value is generated in the linear quantization unit generator 102 and the non-linear quantization unit generator 103. Utilizing the quantization unit thus obtained, the reverse quantization unit 302 performs the reverse quantization of the quantization value input from the quantization input unit 301, and then outputs the result to the output unit 303.

[0033] Therefore, the image decoding apparatus of Embodiment 15 realizes the reverse quantization of non-linear quantization without ROM tables and the like, as in the aforesaid coding apparatus. It is therefore able to realize a decoding circuit with a considerably small circuit.

[0034] Thus in the image coding apparatus and the image decoding apparatus of Embodiment 15, a predictive value for an input data based on the peripheral data is generated in the predictive value generator 106. The linear quantization unit generator 102 and the non-linear quantization unit generator 103 provide that after a quantization representative point is set by linear processing, quantization representative values are added in the vicinity of the predictive value to obtain the non-linear quantization unit generator whose quantization width is small only in the vicinity of the predictive value, thereby performing the quantization or the reverse quantization. Since Embodiment 15 is basically executed in the operation processing utilized in linear quantization, there is required no ROM tables and the like. Required are only a simple adder, subtracter and comparator. By reducing the circuit scale, it is able to reduce costs and electric power and to realize high-speed processing. In the quantization and the reverse quantization, the object of the processing is input values, not differences. Therefore even when the predictive value is incorrect, the above mentioned small circuit can minimize the error propagation without lowering the compressive rate.

Embodiment 16

[0035] An image coding apparatus and an image decoding apparatus of Embodiment 16 are those in which a quantization representative point is added to a linear quantizing unit to realize a non-linear quantization unit for obtaining quantization values, like in Embodiment 15. These apparatuses prevent a decrease in dynamic range by a shift function.

[0036] Referring to Figure 19, there is shown the construction of the image decoding apparatus of Embodiment 16. A shift value generator 107 generates a shift value according to a specified system. Others are common to Figure 16, and the descriptions are the same as those of Embodiment 15.

[0037] The operation of the image coding apparatus so constructed will be described. Similar to Embodiment 15, assuming that an input pixel value is indicated in 8-bit (d) and the quantization value after the coding is 6-bit (n), wherein $n-6$, $k-d-n=2$, and the addition upper bound number $m=5$.

[0038] When a pixel value is input from the pixel value input unit 101, the predictive value generator 106 generates a predictive value of 8-bit as a linear sum that is obtainable from the quantization values of the peripheral pixels. Based on the predictive value thus generated, the shift value generator 107 generates a shift value that is obtained according to a specified system. Based on the shift predictive value that is obtained by subtracting the above shift value from the above predictive value, the linear quantization unit generator 102 and the non-linear quantization unit generator 103 set quantization representative values for an shift input value that is obtained by subtracting the above shift value from the input pixel value.

[0039] Referring to Figures 20(a) to 20(d), there are shown an example of the setting of the quantization representative point in Embodiment 16. Embodiment 16 differs from Embodiment 15 in that the shift predictive value is used in place of the predictive value.

[0040] The quantization unit 104 selects the nearest quantization representative value of a shift input value, and outputs an allocated quantization value to the output unit 105.

[0041] In the image coding apparatus of Embodiment 16, the quantization representative values are basically added only in the vicinity of the shift predictive value by linear quantization, like Embodiment 15. Even non-linear quantization, there is required no ROM tables and the like. Further, since the input pixel value is shifted and its resulting value is directly quantized, error propagation during predictive coding is satisfactorily prevented.

[0042] Referring to Figure 21, there is shown the construction of the image decoding apparatus of Embodiment 16, in which the above coded data is decoded. The shift value generator 107 is the same as that of the image coding apparatus. Others are common to Figure 18.

[0043] A description will be given of the operation of

the image decoding apparatus of Embodiment 16. When a quantization value, i.e., the result of the coding, is input from the quantization value input unit 301, the predictive value generator 106 generates, as a linear sum, a predictive value for the input quantization value by utilizing the peripheral pixels. Based on the predictive value, the shift value generator 107 generates a shift value according to a specified system.

[0044] Similar to the image coding apparatus, the linear quantization unit generator 102 and the non-linear quantization unit generator 103 provide a non-linear quantization unit whose quantization width is small only in the vicinity of the predictive value. Utilizing the obtained non-linear quantization unit, the reverse quantization unit 302 performs the reverse quantization of the quantization value input from the quantization value input unit 301. To the value thus obtained, the shift value is added, followed by decoding. Its result is output to the output unit 303.

[0045] The image decoding apparatus of Embodiment 16 realizes, like Embodiment 15, the reverse quantization of non-linear quantization without ROM tables and the like. It is therefore able to realize a decoding circuit with a considerably small circuit.

[0046] Thus in the image coding and decoding apparatuses of Embodiment 16, the linear quantization unit generator 102 and the non-linear quantization unit generator 103 provide the non-linear quantization by operation processing. It is therefore possible to reduce the circuit scale. This enables to reduce costs and electric power and to satisfactorily prevent the error propagation during the predictive coding.

[0047] Embodiment 16 further provides the following advantage. Based on the predictive value generated in the predictive value generator 106, the shift value generator 107 generates a shift value according to a specified system. Whereas in generating a non-linear quantization unit, instead of such a predictive value, there is employed a shift predictive value that is obtained by subtracting a shift value from a predictive value, thereby avoiding the limit of the dynamic range.

[0048] Specifically, Embodiment 15 realizes the non-linear quantization with a small circuit and can prevent the error propagation during the predictive coding. In Embodiment 15, however, the maximum number of the linear quantization representative points is obtained by reducing the number of the quantization representative points to be added from the original setting number of 2^k , furthermore, the setting is executed around a predictive point. As a result, in a dynamic range, an area exceeding the maximum quantization representative value and an area below the minimum quantization representative value are substantially beyond the object, whereby the dynamic range is restricted.

[0049] Whereas in Embodiment 16, the shift of a predictive value due to a shift value allows to extend such a restricted dynamic range in the direction of the shift, leading to the recovery of the range. It is therefore possible to provide dynamic range equivalent to that of the case

in which linear quantization is mainly performed.

Embodiment 17

5 [0050] An image coding apparatus of Embodiment 17 is for obtaining a non-linear quantization value by a linear quantization value generator and a non-linear quantization value generator.

10 [0051] Referring to Figure 22, there is shown the construction of the image decoding apparatus of Embodiment 17. A linear quantization value generator 401 generates a linear quantization value by the division processing of input pixel value. The generator 401 determines an offset value by the remainder of the division processing, and includes an offset value adding means for adding the offset value to the input pixel value. A non-linear quantization value generator 402 generates a non-linear quantization value by correcting the above linear quantization value with the difference between the input pixel value and a predictive value. Others are common to Figure 16, and the descriptions are the same as those of Embodiment 15.

15 [0052] The image coding apparatus so constructed will operate as follows. When a pixel value is input from a pixel value input unit 101, a predictive value generator 106 generates a predictive value of 8-bit utilizing the peripheral pixels of the input pixel, as a linear sum obtained from the quantization values of the peripheral pixels. The input pixel value from the input unit 101 is also input to the linear quantization value generator 401, in which by the offset value adding means an offset value determined by lower k-bit of the predictive value is added to the input pixel value and then divided with 2^k to be converted into a linear quantization value. The "k" is obtained as the difference between the bit number of the dynamic range of the input pixel value and that of the quantization value to be output.

20 [0053] The linear quantization value is then input to the non-linear quantization value generator 402 to be corrected based on the difference value between the input pixel value and the predictive value, converted into a non-linear quantization value and then output from the output unit 105.

25 [0054] A description will be given of the algorithm for image coding. Similar to Embodiment 15, assuming that the input pixel value is indicated by 8-bit (d), and the quantization value after the coding is 6-bit (n) ($n=6, k=d-n=2$). As shown in Figures 23(a) to 23(d), when setting quantization representative values, to linear quantization representative values with quantization width of 4, there are set six quantization representative values consisting of four quantization representative values with quantization width of 1, adjacent to a predictive value (i.e., 13 in Figures 23(a) to 23(d)), and two quantization representative values with quantization width of 2.

30 [0055] Referring to Figure 24, there is shown a flow chart of the algorithm of the image coding according to Embodiment 17. The quantization operation of the image

coding apparatus will be described. In Figure 24, $P(t)$ denotes the predictive value generated at time t , $I(t)$ denotes the input pixel value generated at time t , $Q(t)$ denotes the input pixel value generated at time t , RO denotes an offset value and IQ denotes a linear quantization value. For the sake of simplicity, assuming that there is used a regenerated value of immediately before. The regenerative value can be obtained from the predictive value by executing the algorithm.

[0056] In step S1 in Figure 24, the offset value adding means of the linear quantization value generator 401 determines an offset value from lower 2-bit of the predictive value $P(-1)$ obtained from the regenerated value at the time immediately before. In step S2, the offset value is added to the input pixel value by the offset value adding means, and the result is divided by 2^2 in the linear quantization value generator 401, to obtain a linear quantization value.

[0057] From step S3, the correction is performed by the non-linear quantization value generator 402. In step S3, the difference between the predictive value and the input pixel value is obtained. In step S4, the obtained difference is determined whether it is positive or negative. In step S5 or S6, a correction value is obtained. Based on the results, a correction value for the quantization value is operated in step S7, and a regenerative value is operated in step S8. In step S9 and S10, it is determined whether either value is adopted based on the difference value previously obtained. As a result, either of steps S10, S12 and S13 is executed to obtain a quantization value.

[0058] As described above, the conversion of the input pixel value into the quantization value is completed. Also in step S10, S12 or S13, a regenerative value $P(O)$ is obtained, and in step S14, the regenerative value is then feedbacked so as to use as a predictive value. Then, the operation for obtaining the next quantization value is repeated.

[0059] As can be seen from the above algorithm, the image coding apparatus of Embodiment 17 can be executed only by simple add-subtract and the comparison. Although non-linear quantization is employed, there is required no complex circuit such as ROM tables. This algorithm provides the value equivalent to the linear quantized input pixel value as a quantization value, so that the influence of error propagation hardly occurs.

[0060] Referring to Figure 25, there is shown the construction of the image decoding apparatus of Embodiment 17. A linear regenerative value generator 601 generates a linear quantization value for the input quantization value. The generator 601 includes an offset value adding means in which an offset value is determined by the remainder of the division operation of a predictive value, and the offset value is added to a linear regenerative value. A non-linear quantization regenerative value generator 602 performs a correction by the difference value between an input quantization value and a predictive value linear quantization value. A predictive value quanti-

zation value generator 603 performs a division operation of the predictive value to obtain a predictive linear quantization value. A quantization value input unit 301, an output unit 303 and a predictive value generator 106 are common to Figure 18, and the descriptions is the same as those of

Embodiment 15.

[0061] A description will be given of the operation of the image decoding apparatus of Embodiment 17.

[0062] The offset value adding means in the linear regenerative generator 601 finds a specified offset value against lower k -bit of the predictive value of the predictive value generator 106. The generator 601 performs a multiplication operation of an input quantization value from the quantization value input unit 301 to obtain the value of 2^k , and adds the above offset value to the value 2^k to convert it into a linear quantization regenerative value, and outputs it to the non-linear quantization value generator 602.

[0063] The generator 602 divides the predictive value by 2^k to obtain a predictive linear quantization value, and outputs it to the non-linear quantization value generator 602. The generator 602 adds a correction value generated from the difference value between the input quantization value and the predictive linear quantization value to a linear quantization regenerative value or a predictive value, to obtain a quantization regenerative value, and then outputs it to the output unit 303.

[0064] A description will be given of the algorithm for image decoding. Assuming that an input pixel value at the coding and a regenerative value are indicated in 8-bit (d), a regenerative value after the decoding is indicated in 8-bit, and the quantization value after the coding is indicated in 6-bit (n) ($n=6$, $k=d-n=2$). In setting quantization representative values, similar to the coding apparatus, six quantization representative values are added and then provided, as shown in Figure 23.

[0065] Referring to Figure 26, there is shown a flow chart of the algorithm for image decoding in Embodiment 17.

According to the flowchart, a description will be given of the algorithm for non-linear quantization value operation. Assuming that $P(t)$ denotes a quantization regenerative value and a predictive value each being generated at time t , $Q(t)$ denotes an input quantization value input at time t , RO denotes an offset value, PQ denotes a predictive value linear quantization value and IQ denotes a linear regenerative value. For the sake of simplicity, assuming that the regenerative value at immediately before is used as a predictive value.

[0066] In step S1, the offset value adding means in the linear regenerative value generator 601 sets an offset value by lower 2-bit of the predictive value $P(-1)$ obtained from the quantization regenerative value of immediately before. In step S2, the predictive value is divided by 2^2 in the predictive value linear quantization value generator

603 to obtain a predictive value linear quantization value PQ.

[0067] From step S3, the correction is performed in the non-linear quantization regenerative value generator 602. In step S3, a difference value between the predictive value linear quantization value and the input quantization value is obtained. In step S4, it is determined whether the difference is positive or negative. In step S5 or S6, a correction value is obtained. Based on the results, the operation of a correction regenerative value is operated in step S7, and steps S8 and S10, based on the obtained difference value, it is determined whether either value should be adopted. Step S9, S11 or S12 is executed to obtain a quantization regenerative value.

[0068] As described above, the processing for decoding the input quantization value into the quantization regenerative value is executed. The obtained quantization regenerative value is feededback in step S13, whereby the operation for obtaining the next quantization regenerative value is repeated.

[0069] Although the image decoding algorithm employs a non-linear quantization, there is required no ROM table for the reverse quantization. Required are only simple add-subtract. Therefore, irrespective of the suitable change of the quantization representative value due to a predictive value, the decoding processing can be realized with a considerable small circuit.

[0070] In the image coding apparatus of Embodiment 17, the predictive value against the input data is generated based on the peripheral data in the predictive value generator 106. The linear quantization value generator 401 and the non-linear quantization value generator 402 provide that after the quantization representative value is set by the linear processing, and the quantization representative value is added to the vicinity of the predictive value to perform a non-linear quantization whose quantization width is small only in the vicinity of the predictive value, thereby obtaining a quantization value. This is executed by the operation processing used basically in linear quantization. Hence, without ROM tables and the like, the apparatus can be realized by a simple adder-subtractor. It is therefore possible to reduce the size of the circuit, leading to reduced cost and electric power, permitting a high-speed processing.

[0071] In the image decoding apparatus of Embodiment 17, a linear quantization regenerative value is obtained by the linear processing in the linear regenerative value generator 601, a predictive value linear quantization value is obtained in the predictive value linear quantization value generator 603 based on a predictive value generated in the predictive value generator 106. Based on the results, the correction is executed in the non-linear quantization regenerative value generator 602 based on the difference value between the input quantization value and the predictive linear quantization value, to obtain a quantization regenerative value. It is therefore possible to realize the reverse quantization with a small circuit and to reduce costs and electric power.

[0072] In the quantization and the reverse quantization there is processed an input value not a difference. Even when the predictive value is incorrect, the error propagation can be minimize without reducing the compressive rate. This enables to realize with such a small circuit as described.

Embodiment 18

[0073] An image coding apparatus of Embodiment 18 is for obtaining a quantization representative value by the linear quantization value generator and the non-linear quantization value generator, like in Embodiment 17. The apparatus prevents a decrease in dynamic range by a shift function.

[0074] Referring to Figure 27, there is shown the construction of the image decoding apparatus of Embodiment 18. A shift value generator 107 generates a shift value according to a specified system. Others are common to Figure 22, and the descriptions are the same as those of Embodiment 17.

[0075] The image coding apparatus so constructed will operate as follows. When a pixel value is input from a pixel value input unit 101, a predictive value generator 106 generates a predictive value of 8-bit utilizing the peripheral pixels of the input pixel, as a linear sum obtained from the quantization values of the peripheral pixels. Based on the generated predictive value, the shift value generator 107 generates a shift value by a specified system. While a shift input value obtained by subtracting the shift value from the input pixel value from the pixel value input unit 101, is input to a linear quantization value generator 401 and, by the offset value adding means, there is added an offset value determined by lower k-bit of the predictive value, and then divided by 2^k to be converted into a linear quantization value. The "k" is obtained as the difference between the hit number of the dynamic range of the input pixel value and that of the quantization value to be output.

[0076] The linear quantization value is then input to the non-linear quantization value generator 402 to be corrected based on the difference value between the input pixel value and the predictive value, converted into a non-linear quantization value and then output from the output unit 105.

[0077] A description will be given of the algorithm for image coding. Similar to Embodiment 17, assuming that the input pixel value is indicated by 8-bit (d), and the quantization value after the coding is 6-bit (n) ($n=6$, $k=d-n=2$). When setting quantization representative values, like Embodiment 17, there are added six quantization representative values consisting of four quantization representative values with quantization width of 1, and two quantization representative values with quantization width of 2. It is noted that the predictive value is employed instead of the shift predictive value.

[0078] Referring to Figure 28, there is shown a flow chart of the algorithm of the image coding according to

Embodiment 18. The quantization operation of the image coding apparatus will be described. In Figure 28, $P(t)$ denotes the predictive value generated at time t , Sf is a shift value obtained from the predictive value, $I(t)$ denotes the input pixel value generated at time t , $Q(t)$ denotes the input quantization value generated at time t , RO denotes an offset value and IQ denotes a linear quantization value. For the sake of simplicity, assuming that there is used a regenerative value of immediately before. The regenerative value can be obtained from the predictive value by executing the algorithm.

[0079] In step S1 in Figure 28, the shift value generator 107 determines a shift value Sf from upper 5-bit of the obtained predictive value $P(-1)$ obtained from the regenerative value of immediately before. In step S2, a shift input value obtained by subtracting the shift value from the input pixel value, and a shift predictive value obtained by subtracting the shift value from the predictive value. In step S3, the offset value adding means in the linear quantization value generator 401 sets an offset value by lower 2-bit of the shift predictive value. In step S4, after the offset value is added to the shift input value in the offset value adding means and the result is divided by 2^2 in the linear quantization value generator 401, to obtain a linear quantization value.

[0080] From step S5, the correction is performed by the non-linear quantization value generator 402. In step S5, the difference between the predictive value and the input pixel value is obtained. In step S6, the obtained difference is determined whether it is positive or negative. In step S7 or S8, a correction value is obtained. Based on the results, a correction value for the quantization value is operated in steps S8 and S9, and a regenerative value is operated in step S10. In steps S11 and S13, it is determined whether either value is adopted based on the difference value previously obtained. As a result, either of steps S12, S14 and S15 is executed to obtain a quantization value.

[0081] As described above, the conversion of the input pixel value into the quantization value is completed. Also in step S12, S14 or S15, a regenerative value $P(O)$ to which the shift value has been added is obtained, and in step S16, the regenerative value is then feedbacked so as to use as a predictive value. Then, the operation for obtaining the next quantization value is repeated.

[0082] As can be seen from the above algorithm, the image coding apparatus of Embodiment 18 can be executed only by simple add-subtract and the comparison. Although non-linear quantization is employed, there is required no complex circuit such as ROM tables. This algorithm also provides the value equivalent to the linear quantized input pixel value as a quantization value, so that the influence of error propagation hardly occurs.

[0083] Referring to Figure 29, there is shown the construction of the image decoding apparatus of Embodiment 18. A shift value generator 107 generates a shift value by a specified system. Others are common to Figure 25, and the descriptions are the same as those of

Embodiment 17.

[0084] A description will be given of the operation of the image decoding apparatus of Embodiment 18. The shift value generator 107 generates shift value by a specified system, based on the predictive value generated in the predictive value generator 106. The offset value adding means in the linear regenerative generator 601 finds a specified offset value based on lower k -bit of the shift predictive value. The generator 601 performs a multiplication operation of an input quantization value from the quantization value input unit 301 to obtain the value of 2^k , and adds the above offset value to the value 2^k to convert it into a linear quantization regenerative value, and outputs it to the non-linear quantization value generator 602.

[0085] The generator 602 divides the predictive value by 2^k to obtain a predictive linear quantization value, and outputs it to the non-linear quantization value generator 602. The generator 602 adds a correction value generated from the difference value between the input quantization value and the predictive linear quantization value to a linear quantization regenerative value or a predictive value, to obtain a quantization regenerative value, and then outputs it to the output unit 303.

[0086] A description will be given of the algorithm for image decoding. Assuming that an input pixel value at the coding and a regenerative value are indicated in 8-bit (d), and a quantization value after the coding is indicated in 6-bit (n) ($n=6$, $k=d-n=2$). In setting quantization representative values, six quantization representative values are added to be arranged, as in the image coding apparatus.

[0087] Referring to Figure 30, there is shown a flow chart of the algorithm for image decoding in Embodiment 18. According to the flowchart, a description will be given of the algorithm for non-linear quantization value operation. Assuming that $P(t)$ denotes a quantization regenerative value and a predictive value each being generated at time t , $Q(t)$ denotes an input quantization value input at time t , RO denotes an offset value, PQ denotes a predictive value linear quantization value, Sf denotes a shift value obtained from the predictive value and IQ denotes a linear regenerative value. For the sake of simplicity, assuming that the regenerative value at immediately before is used as a predictive value.

[0088] In step S1 in Figure 30, the shift value generator 107 determines a shift value Sf by upper 5-bit of the predictive value $P(-1)$ obtained from the regenerative value at immediately before the time. In step S2, the shift value is subtracted from the predictive value to obtain a shift predictive value. In step S3, the offset value adding means in the linear regenerative value generator 601 determines an offset value by lower 2-bit of the predictive value $P(-1)$ obtained from the quantization regenerative value at immediately before the time. In step S4, the shift predictive value is divided by 2^2 in the predictive value linear quantization value generator 603 to obtain a predictive value linear quantization value PQ .

[0089] From step S5, the correction is carried out in the non-linear quantization regenerative value generator 602. In step S5, a difference value between the predictive value linear quantization value and the input quantization value is obtained. In step S6, it is determined whether the difference value is positive or negative. In step S7 or S8, a correction value is obtained. Based on the results, a correction regenerative value is operated in step S9. In steps S10 and S12, it is determined from the difference value whether either value should be adopted. Step S11, 13 or 14 is executed to obtain a quantization regenerative value, a shift value is added thereto and the result is output.

[0090] Although the image decoding algorithm employs a non-linear quantization, there is required no ROM table for the reverse quantization. Required are only simple add-subtract. Therefore, irrespective of the suitable change of the quantization representative value due to a predictive value, the decoding processing can be realized with a considerable small circuit.

[0091] In the image coding apparatus of Embodiment 18, the predictive value against the input data is generated based on the peripheral data in the predictive value generator 106. The linear quantization value generator 401 and the non-linear quantization value generator 402 provide that after the quantization representative value is set by the linear processing, and the quantization representative value is added to the vicinity of the predictive value to perform a non-linear quantization whose quantization width is small only in the vicinity of the predictive value, thereby obtaining a quantization value. Thus, like Embodiment 17, the realization of the non-linear quantization processing at a small circuit allows to reduce costs and electric power. This permits a high-speed processing and enables to satisfactorily prevent the error propagation during the predictive coding.

[0092] In the image decoding apparatus of Embodiment 18, a linear quantization regenerative value is obtained by the linear processing in the linear regenerative value generator 601, a predictive value linear quantization value is obtained in the predictive value linear quantization value generator 603 based on a predictive value generated in the predictive value generator 106. Based on the results, the correction is executed in the non-linear quantization regenerative value generator 602 based on a difference value between the input quantization value and the predictive linear quantization value, to obtain a quantization regenerative value. It is therefore possible to realize the reverse quantization with a small circuit and to reduce costs and electric power.

[0093] Furthermore in the apparatus of Embodiment 18, based on a predictive value generated in the predictive value generator 106, the shift value generator 107 generates a shift value by a specified system. In generating a non-linear quantization unit, a shift predictive value that is obtained by subtracting the shift value from the predictive value is employed instead of the predictive value. Therefore, a dynamic range restricted by a decrease

of a linear quantization representative value can be recovered by extending the range to the shift direction. This realizes a dynamic range equivalent to that of the case in which linear quantization is mainly performed, like **Embodiment 16.**

[0094] It should be noted that although the correction for obtaining the non-linear quantization value or non-linear quantization regenerative value is carried out based on the difference value between a shift input value and a shift predictive value, it may be based on a difference value between a shift value and a predictive value, resulting in the same effect.

Embodiment 19

[0095] An image coding apparatus and an image decoding apparatus of Embodiment 19 are those in which quantization representative points are added to a linear quantizing unit to realize a non-linear quantization unit for obtaining a quantization value, and are provided with a function to set quantization representative points to a specific area.

[0096] Referring to Figure 31, there is shown the construction of the image decoding apparatus of Embodiment 19. A non-linear quantization unit generator 701 generates a non-linear quantization unit in which quantization representative points are added to a specific area in addition to the vicinity of a predictive point. Others are common to Figure 16, and the descriptions are the same as those of Embodiment 15.

[0097] The image coding apparatus so constructed will operate as follows. Similar to Embodiment 15, assuming that an input pixel value is indicated in 8-bit (d), a quantization value after the coding is indicated in 6-bit (n) wherein $n=6$, $k=d-n=2$; $m=5$ wherein m is the number that has been previously set for setting quantization representative values to be added; and $p=3$ wherein p is a second addition upper bound number that has been previously set for adding quantization representative points to a specific area.

[0098] The operations up to the linear quantization unit having linear quantization representative values is generated in the linear quantization unit generator 102, are common to Embodiment 15. The linear quantization representative values are generated with the quantization width of 4 (2^2), resulting in 59 (2^6-5).

[0099] Referring to Figures 32(a), there is shown a setting of quantization representative values by the linear quantization unit generator 102. In this case, an area ranging from -128 to -119 and an area ranging from 119 to 127 are beyond the area to be selected as quantization representative values.

[0100] The non-linear quantization unit generator 701 adds quantization representative values to linear quantization representative values. That is, not more than m -p quantization representative points are added in the vicinity of the predictive value such that the quantization width near the predictive value becomes smaller than

that of the linear quantization unit. In this example, in the range of two levels across the predictive value of 13, two ($m-p=2$) quantization representative values, i.e., 11 and 15, are added as shown in Figure 32(b). As a result, only in the vicinity of the predictive value, the quantization width turns to be 2, while that of the other area is 4. The quantization representative points total 61.

[0101] Subsequently the non-linear quantization unit generator 701 adds each one quantization representative value to the area ranging from -128 to -119 and the area ranging from 119 to 127 ($2 < p=3$). The quantization width of these area turns to be 8. As a result, the quantization representative values total 63 ($< 2^6$), whereby the quantization value as the coding result is indicated by 6-bit.

[0102] As shown in Figure 32(c), the quantization value allocated for the area ranging from -128 to -119 is -31 being the minimum. The quantization representative values are allocated in increasing order like Embodiment 1, so that 31 is allocated for the area ranging from 119 to 127.

[0103] Subsequently the quantization in the quantization unit 104 and the output to the output unit 108 are carried out in the same manner as in Embodiment 1.

[0104] Referring to Figure 33, a description will be given of the image decoding apparatus of Embodiment 19 in which the above coded data is decoded.

[0105] A non-linear quantization unit generator 701 is the same as that of the image coding apparatus. Others are common to Figure 18.

[0106] The operation of the image decoding apparatus of Embodiment 19 is the same as that of Embodiment 15, except that the quantization representative values of the non-linear quantization unit generated in the non-linear quantization unit generator 701 are those which are shown in Figures 32(a) to 32(d).

[0107] There is required no ROM table and the like, thereby realizing the decoding processing at a small circuit.

[0108] As described above, the image coding and decoding apparatuses of Embodiment 19 are provided with the non-linear quantization unit generator that functions to add quantization representative values to a specific area. Therefore, the dynamic range restriction due to the addition of the quantization representative values to the vicinity of a predictive value, can be reduced by the construction having no function of generating shift values in Embodiment 16.

Embodiment 20

[0109] An image coding apparatus and an image decoding apparatus of Embodiment 20 are those in which non-linear quantization values are obtained by a linear quantization value generator and a non-linear quantization value generator, and a specified coding or decoding is carried out in reply to the input of a specific area.

[0110] Referring to Figure 34, there is shown the con-

struction of the image decoding apparatus of Embodiment 20. An input restriction unit 403 examines the magnitude of an input pixel value from a pixel value input unit. When it is within a specified range, the restriction unit 403 outputs the input pixel value to a linear quantization value generator 401, and, when it is beyond the range, does not output the input pixel value but outputs a specified quantization value to a non-linear quantization value generator 402. When the quantization value is output from the restriction unit 403, the generator 402 outputs it to an output unit 105. Others are common to Figure 22, and the descriptions are the same as those of Embodiment 17.

[0111] A description will be given of the operation of the image coding apparatus so constructed. Like Embodiment 17, assuming that an input pixel value is indicated in 8-bit (d), a quantization value after the coding is indicated in 6-bit (n) wherein $n=6$, $k=d-n-2$, the addition upper bound m is 5, and a second addition upper bound number p is 3.

[0112] When a pixel value is input from the pixel value input unit 101, the predictive value generator 106 generates a predictive value of 8-bit by utilizing pixels around the input pixel. The input pixel value from the input unit 101 is also input to the input value restriction unit 403 and then determined whether it is within a specified range.

[0113] At that time, when the input pixel value is within the range, the input pixel value is input to the linear quantization unit 401, and there is added an offset value which is determined by lower k-bit of the predictive value in the unit 401. Like in Embodiment 17, the obtained value is converted into a linear quantization value by division processing, which value is then corrected in the non-linear quantization value generator 402, based on a difference value between the input value and the predictive value, so that it is converted into a non-linear quantization value and then output from the output unit 106.

[0114] On the other hand, when the input pixel value is outside of the specified range, the input value restriction unit 403 generates a non-linear quantization value by a specified system, which value is then input to the generator 402 and output from the output unit 105.

[0115] Referring to Figure 36(a), when an input pixel value is in the range of from -118 to 118, the input value restriction unit 403 outputs it to the linear quantization value generator 401. The output pixel value is then processed in the generator 401 and the non-linear quantization value generator 402, like the coding apparatus of Embodiment 17, thereby obtaining a quantization value.

[0116] When an input pixel value is in the range of from -128 to -119, or from 119 to 127, the restriction unit 403 does not output it to the generator 401, but generates the non-linear quantization values "-31" or "31", and outputs it to the generator 402. This results in the same coding result like Embodiment 19.

[0117] Referring to Figure 35, a description will be given of the image decoding apparatus of Embodiment 20

in which the above coded data is decoded. When a specific quantization value is input, a non-linear quantization value generator 1201 outputs a specified regenerative value. Others are common to Figure 25.

[0118] When a specific one is input to the quantization value input unit 301, the unit 301 outputs it to the non-linear quantization value generator 1201, and the generator 1201 outputs a specified regenerative value to the output unit 308. The above specific one is a specified non-linear quantization value that is output to the non-linear quantization value generator 402 from the input value restriction unit 403. Other cases are processed in the same operation as in the image decoding apparatus of Embodiment 17.

[0119] Referring to Figure 36(b), when the quantization value input to the quantization value input unit is neither -31 nor 31, the same processing as in Embodiment 17 is executed to obtain a regenerative value, which is then output. When it is -31 or 31, the non-linear quantization regenerative value generator 1201 outputs -123 and 123, respectively, to the output unit 308. This results in the same decoding result as in Embodiment 19.

[0120] The image coding and decoding apparatuses of Embodiment 20 requires no ROM table and the like, thereby realizing the coding/decoding processing at a small circuit. In addition, the apparatuses function to output a specified value against the input pixel value or quantization value of a specific area. Hence the dynamic range restriction due to the addition of quantization representative values to the vicinity of a predictive value, can be reduced by the construction having no function of generating shift values in Embodiment 16.

Embodiment 21

[0121] The image coding apparatus of Embodiment 21 is provided with an input restriction function.

[0122] The image coding apparatus of Embodiment 15 realizes the non-linear quantization by adding quantization representative values to the vicinity of a predictive values of the quantization representative values obtained by linear quantization. The number of linear quantization representative values is reduced by the number of quantization representative values to be added. Thus the range of quantization in the linear quantization, i.e., dynamic range, should be restricted.

[0123] Referring to Figure 37, there is shown the construction of the image coding apparatus of Embodiment 21. An input value restriction unit 403 restricts the input value. An image coding unit 702 comprises the linear quantization unit generator, the non-linear quantization unit generator, the quantization unit and the predictive value generator as shown in Embodiment 15. A pixel value input unit 101 and an output unit 105 are common to Figure 16.

[0124] The image coding apparatus of Embodiment 21 performs the coding in the following operations. The input pixel value from the pixel value input unit 101 is input to

the input value restriction unit 403, and then restricted to the range for which the quantization can be executed in the linear quantization unit of the image coding unit 702. The restricted input value is converted into a quantization value in the coding unit 702, in the same coding processing as in Embodiment 15. The obtained value is output to the output unit 105.

[0125] When m quantization representative points are added in the non-linear quantization unit, the restriction in the restriction unit 403 should be executed so that the dynamic range of the input pixel value is reduced by at least $m \times 2^k$ levels.

[0126] As described above, in the image coding apparatus of Embodiment 21, the input value restriction unit 403 restricts the input pixel values to the range capable of being processed by the linear quantization. It is therefore able to satisfactorily hold the characteristic that a fine image quality is obtainable from the predictive coding in the non-linear quantization processing that prevents the error propagation due to a small circuit.

[0127] It is noted that although the image coding unit 702 is constructed according to Embodiment 15, it may be constructed according to Embodiment 17, resulting in the same effect.

Embodiment 22

[0128] The image coding apparatus of Embodiment 22 is provided with a function to restrict a quantization value.

[0129] Referring to Figure 38, there is shown the construction of the image coding apparatus. A quantization value restriction unit 801 restricts a quantization value. Others are common to Figure 37.

[0130] The coding is carried out in the following. When an input pixel value is input from the pixel value input unit 101, the coding unit 702 converts the input pixel value into a quantization value in the same coding processing as in Embodiment 15, and the obtained value is input to a quantization value restriction unit 801. The unit 801 detects the value of the input quantization value and, when it is outside a range of from the minimum value to the maximum value determined to the quantization value, the detected value is restricted to the range and then output to the output unit 105.

[0131] Thus in Embodiment 22, the quantization value as the coding result is restricted to a specific range by the quantization value restriction unit 801, thereby omitting the restriction of the dynamic range of an input value. This enables to obtain the same effect as in Embodiment 21.

[0132] It is noted that although the image coding unit 702 is constructed according to Embodiment 15, it may be constructed according to Embodiment 17, resulting in the same effect-

Embodiment 23

[0133] The image coding apparatus of Embodiment 23

is provided with a function to restrict shift input.

[0134] The construction of the apparatus is common to Embodiment 18, the description will be given referring to Figure 27. The linear quantization value generator 102 includes the shift input value restriction means that re-

stricts the shift input value obtained from an input pixel value and a shift value to a specific range. Others are common to Embodiment 18.

[0135] Referring to Figure 39, there is shown a flow

chart illustrating the coding algorithm of the image coding

apparatus of Embodiment 23. The flow of Figure 39 dif-

fers from that of Figure 28 in that the range of a shift input

value is restricted in step S2. Others are common to Em-

bodiment 18.

[0136] Thus in Embodiment 23, the shift input restric-

tion function provides the effect similar to the input re-

striction function of Embodiment 21. In the apparatus of

Embodiment 21, however, when input data is determined

as non-object by the fixed setting of the input restriction

unit, such input data is never employed in the succeeding

processing. Whereas in Embodiment 23 the shift input

restrictions realizes the restriction depending on the shift

value setting, permitting a further flexible application.

[0137] It is noted that although Embodiment 23 is con-

structed according to Embodiment 18, it may be con-

structed according to Embodiment 16, resulting in the

same effect.

Embodiment 24

[0138] The image coding and decoding apparatus of Embodiment 24 is able to set error codes.

[0139] The construction of the image coding apparatus is same as that of Embodiment 22, and it will be described referring to Figure 38. In Embodiment 24 so constructed, a quantization value restriction unit 801 enables to prohibit the use of a pattern of a specified n-bit in a normal quantization. This further enables to allocate an error code showing an error in a quantization value, to such a pattern not to be used. In a case where a quantization value is in 6-bit, the numerals from -31 to 31 are utilized in the quantization, and -32 is set to an error code.

[0140] Referring to Figure 40, there is shown the construction of the image decoding apparatus of Embodiment 24 in which the error code processing is executed.

An image decoding unit 901 comprises the linear quantization unit generator, the non-linear quantization unit generator and the predictive value generator shown in Figure 18, and the unit 901 performs the same decoding processing as the image decoding apparatus of Embodiment 15. An error code detector 902 detects an error code of an input quantization value. A predictive error setting unit 903 sets a difference from a predictive value.

[0141] A description will be given of the decoding processing in the decoding apparatus of Embodiment 24. An input quantization value from the quantization value input unit 301 is first determined whether it is error code or not in the error code detector 902. For an error

code, the difference from a predictive value is set to be 0 in the image decoding unit 901 through the predictive error setting unit 903, thereby outputting the predictive value as it is to the output unit 303. When an input quantization value is not an error code, a normal decoding is carried out in the decoding unit 901 and its result is output to the output unit 303.

[0142] In the above processing, when an error code is detected, the predictive value is output as a regenerative value.

[0143] When an error is contained in the data coded by the image coding apparatus so constructed, parts including such an error is replaced with an error code, whereby the above function of the decoding apparatus is valid.

[0144] Referring to Figure 41, there is shown a circuit for inserting an error code. A regenerative value input unit 9101 regenerates a coded data. An error code replacement unit 9102 replaces a quantization value of a regenerative data with an error code. An error detector 9103 detects an error of a regenerative data. An output unit 9104 outputs data after the replacement.

[0145] In the error code insertion circuit so constructed, the error detector 9103 detects whether there is an error in data regenerated from a magnetic tape or a transmission signal in the input unit 9101. The quantization value whose error is detected in the detector 9103 is then replaced with an error code in the error code replacement unit 9102. In this way, the quantization value that may have an error is replaced with an error code and then output to the output unit 9104.

[0146] Thus the image coding and decoding apparatuses of Embodiment 24 are provided with the quantization value input unit 301, thereby setting a specific quantization value as an error code. The obtained coded data is subjected to the error code replacement processing by the error code insertion circuit as described. Therefore, in the image decoding apparatus provided with the error code detector 902 and the predictive error setting unit 903, when an error code is detected, a predictive value itself is employed as a regenerative value, thereby minimizing the influence of the error.

Embodiment 25

[0147] It should be noted that the image coding and decoding apparatuses as described in the foregoing have many common processing. In Embodiment 25, therefore, there are shown a circuit common to these apparatuses.

[0148] Referring to Figure 42, there is shown the construction common to the coding apparatus and the decoding apparatus. A pixel value input unit 1101, a quantization value input unit 1102, a quantization regenerative value output unit 1103 and a quantization value output unit 1104 are those which are shown in Figure 16 and Figure 18 in Embodiment 15.

[0149] Numerals 1105 to 1112 designate switches, 1113 to 1123 designate adder-subtractors, 1124 and

1125 designate comparators, and 1126 and 1127 designate delay units.

[0150] In the circuit shown in Figure 42, at the quantization (decoding) the switches 1105 to 1110 are connected in "e" direction, while at the reverse quantization (decoding) they are connected to "d" direction. Therefore at the coding, the same processing as the aforesaid image coding algorithm as previously described can be realized, and at the decoding, the same processing as the aforesaid image decoding algorithm can be realized.

[0151] Thus in the common circuit of Embodiment 25, the coding processing and the decoding processing can be switched, permitting to share almost of all circuits. This enables to considerably reduce the circuit size, leading to the reduced costs and effective applications of the device resource.

[0152] While the present invention has been described in terms of particular illustrative embodiments, many other modifications will occur to those skilled in the art without departing from scope of the appended claims. The invention can comply with optional image signal. As to the method of generating a predictive value, the bit numbers of an input pixel value and a quantization value and the like, optional methods other than the embodiments are applicable. The constructions illustrated in the embodiments can be realized in a variety of methods and processing order, and also be realized by software. Additionally, the image coding apparatus and decoding apparatuses utilizing a combination of the above mentioned plural techniques are available.

Claims

1. An image coding apparatus that codes an input pixel value with a predetermined dynamic range to obtain an N-bit quantization value and transmits it, comprising:

predictive value generation means (106) for generating a predictive value of the input pixel value from pixels in the vicinity of the input pixels; linear quantization level generating means (102) for linearly subdividing said predetermined dynamic range using $2^N - M$ first quantization levels, where M is a predetermined integer upper limit, said first quantization levels differing by a first quantization step; non-linear quantization level generating means (103) for adding up to M second quantization levels to said first quantization levels in the vicinity of said predictive value, said second quantization levels differing by a second quantization step smaller than said first quantization step; and quantization means (104) for quantizing the input pixel value using the quantization levels from said linear and non-linear level generating

means.

2. The image coding apparatus of claim 1 further comprising means for generating a shift value from a predictive value generated by said predictive value generating means, wherein:

said non-linear quantization level generating means adds said quantization levels in the vicinity of a shift predictive value which is obtained by subtracting said shift value from said predictive value; and

said quantization means quantizes a shift input value which is obtained by subtracting said shift value from an input pixel value.

3. The image coding apparatus of claim 1 further comprising input value restriction means that examines whether the magnitude of said input pixel value is in a specified range and, when it is in the range, outputs said input pixel value to said linear quantization level generating means, and when it is outside the range, does not output said input pixel value but outputs a specified restricted quantization value to said non-linear quantization level generating means.

4. The image coding apparatus of claim 1 wherein said linear quantization level generating means has offset value adding means that determines an offset value by a remainder after dividing said predictive value by 2^k , k being an integer, said offset value being added to the linear quantization level of said linear quantization level generating means.

5. The image coding apparatus of claim 1, 3 or 4 further comprising input value restriction means for restricting the magnitude of said input pixel value to output a restricted input value.

6. The image coding apparatus of claim 2 further comprising shift input value restriction means for restricting the magnitude of said shift input value to output a restricted shift input value.

7. The image coding apparatus of claim 1, 2 or 3 wherein said quantization means has quantization value restriction means for restricting the magnitude of the generated quantization value.

8. The image coding apparatus of claim 1, 2 or 3 wherein said quantization means generates a quantization value so that when an input pixel value is minimum, its corresponding quantization value is minimum, and, as increasing the input pixel value, its corresponding quantization value increases.

9. The image coding apparatus of claim 5, 6, 7 or 8 wherein said quantization means defines a specific

n-bit pattern as an error code, said pattern being not used for an output quantization value.

10. An image decoding apparatus that decodes an N-bit quantization value to obtain a regenerative value with a predetermined dynamic range, comprising:

predictive value generating means (106) for generating a predictive value of an input quantization value from pixels in the vicinity of the input quantization value;

linear quantization level generating means (102) for linearly subdividing said predetermined dynamic range using 2^N -M first quantization levels, where M is a predetermined integer upper limit, said first quantization levels differing by a first quantization step;

non-linear quantization level generating means (103) for adding up to M second quantization levels to said first quantization levels in the vicinity of said predictive value, said second quantization levels differing by a second quantization step smaller than said first quantization step; and

reverse quantization means (302) for performing reverse quantizing of the input pixel value using the quantization levels from said linear and non-linear level generating means to obtain a regenerative value.

11. The image decoding apparatus of claim 10 further comprising shift value generating means for generating a shift value from said predictive value wherein:

said non-linear quantization level generating means adds up to M levels in the vicinity of a shift predictive value which is obtained by subtracting said shift value from said predictive value, and adds said shift value to said regenerative value to obtain a pixel value and then outputs it.

12. The image decoding apparatus of claim 11 further comprising shift value generating means for generating a shift value from said predictive value wherein:

said predictive value linear quantization value generating means that divides a shift predictive value which is obtaining by subtracting said shift value from said predictive value, by 2^k , k being an integer, to generate a predictive value linear quantization value, and adds said shift value to said regenerative value to obtain a pixel value and then outputs it.

13. The image decoding apparatus of claim 10, 11 or 12 wherein said linear quantization level generating means has offset value adding means that determines an offset value by a remainder after dividing

said predictive value by 2^k , k being an integer, said offset value being added to the linear quantization level of said linear quantization level generating means.

14. The image decoding apparatus of claim 10, 11 or 12 wherein a specific n-bit pattern is regarded as an error code that is not used in a normal coding, and said predictive value is regarded as said regenerative value when a pattern of said input quantization value agrees with a pattern of said error code.

15. the image decoding apparatus of claim 14 wherein when the input quantization value to be transmitted has a possibility of including an error, said input quantization value is replaced with said error code.

Patentansprüche

1. Bildcodiervorrichtung, die einen eingegebenen Pixelwert mit einem vorgegebenen dynamischen Bereich codiert, um einen N-Bit-Quantisierungswert zu erhalten, und die diesen überträgt, mit:

Prädiktionswert-Erzeugungsmitteln (106) zum Erzeugen eines Prädiktionswerts des eingegebenen Pixelwerts aus Pixeln in der Nähe der eingegebenen Pixel;

Linearquantisierungsnormal- Erzeugungsmitteln (102) zum linearen Unterteilen des vorgegebenen dynamischen Bereichs unter Verwendung von 2^N - M ersten Quantisierungsnormalen, wobei M ein vorgegebener ganzzahliger oberer Grenzwert ist und sich die ersten Quantisierungsnormale durch eine erste Quantisierungsstufe unterscheiden;

Nichtlinearquantisierungsnormal- Erzeugungsmitteln (103) zum Addieren von bis zum M zweiten Quantisierungsnormalen zu den ersten Quantisierungsnormalen in der Nähe des Prädiktionswerts, wobei die zweiten Quantisierungsnormale sich durch eine zweite Quantisierungsstufe unterscheiden, die kleiner als die erste Quantisierungsstufe ist; und

Quantisierungsmitteln (104) zum Quantisieren des eingegebenen Pixelwerts unter Verwendung der Quantisierungsnormale von den Linear- und Nichtlinearquantisierungsnormal-Erzeugungsmitteln.

2. Bildcodiervorrichtung nach Anspruch 1, die weiterhin Mittel zum Erzeugen eines Verschiebewerts aus einem von den Prädiktionswert-Erzeugungsmitteln erzeugten Prädiktionswert aufweisen, **dadurch gekennzeichnet, dass** die Nichtlinearquantisierungsnormal-Erzeugungsmittel die Quantisierungsnormale in der Nähe eines

Verschiebe-Prädiktionswerts addieren, der durch Subtrahieren des Verschiebewerts von dem Prädiktionswert erhalten wird, und die Quantisierungsmittel einen Verschiebe-Eingabewert quantisieren, der durch Subtrahieren des Verschiebewerts von einem eingegebenen Pixelwert erhalten wird.

3. Bildcodiervorrichtung nach Anspruch 1, die weiterhin Eingabewert-Begrenzungsmittel aufweist, die prüfen, ob die Größe des eingegebenen Pixelwerts in einem festgelegten Bereich liegt, und, wenn sie in dem Bereich liegt, den eingegebenen Pixelwert an die Linearquantisierungsnormal-Erzeugungsmittel ausgeben, und wenn sie außerhalb des Bereichs liegt, nicht den eingegebenen Pixelwert, sondern einen festgelegten begrenzten Quantisierungswert an die Nichtlinearquantisierungsnormal-Erzeugungsmittel ausgeben. 10
4. Bildcodiervorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** die Linearquantisierungsnormal-Erzeugungsmittel Offset-Wert-Addiermittel haben, die einen Offset-Wert mittels eines Rests nach dem Dividieren des Prädiktionswerts durch 2^k ermitteln, wobei k eine Ganzzahl ist und der Offset-Wert zu dem Linearquantisierungsnormal der Linearquantisierungsnormal-Erzeugungsmittel addiert wird. 15 20 25
5. Bildcodiervorrichtung nach Anspruch 1, 3 oder 4, die weiterhin Eingabewert-Begrenzungsmittel zum Begrenzen der Größe des eingegebenen Pixelwerts aufweist, um einen begrenzten Eingabewert auszugeben. 30 35
6. Bildcodiervorrichtung nach Anspruch 2, die weiterhin Verschiebe-Eingabewert-Begrenzungsmittel zum Begrenzen der Größe des Verschiebe-Eingabewerts aufweist, um einen begrenzten Verschiebe-Eingabewert auszugeben. 40
7. Bildcodiervorrichtung nach Anspruch 1, 2 oder 3, **dadurch gekennzeichnet, dass** die Quantisierungsmittel Quantisierungswert-Begrenzungsmittel zum Begrenzen der Größe des erzeugten Quantisierungswerts aufweisen. 45
8. Bildcodiervorrichtung nach Anspruch 1, 2 oder 3, **dadurch gekennzeichnet, dass** die Quantisierungsmittel einen Quantisierungswert so erzeugen, dass in dem Fall, dass ein eingegebener Pixelwert minimal ist, auch sein entsprechender Quantisierungswert minimal ist, und wenn der eingegebene Pixelwert steigt, auch sein entsprechender Quantisierungswert steigt. 50 55
9. Bildcodiervorrichtung nach Anspruch 5, 6, 7 oder 8,

dadurch gekennzeichnet, dass die Quantisierungsmittel ein spezielles n -Bit-Muster als einen Fehlercode definieren, wobei das Muster nicht für einen ausgegebenen Quantisierungswert verwendet wird.

10. Bilddecodiertorrichtung, die einen N -Bit-Quantisierungswert decodiert, um einen Regenerationswert mit einem vorgegebenen dynamischen Bereich zu erhalten, mit:

Prädiktionswert-Erzeugungsmitteln (106) zum Erzeugen eines Prädiktionswerts eines eingegebenen Quantisierungswerts aus Pixeln in der Nähe des eingegebenen Quantisierungswerts; Linearquantisierungsnormal-Erzeugungsmitteln (102) zum linearen Unterteilen des vorgegebenen dynamischen Bereichs unter Verwendung von $2^N - M$ ersten Quantisierungsnormalen, wobei M ein vorgegebener ganzzahliger oberer Grenzwert ist und sich die ersten Quantisierungsnormale durch eine erste Quantisierungsstufe unterscheiden; Nichtlinearquantisierungsnormal-Erzeugungsmitteln (103) zum Addieren von bis zum M zweiten Quantisierungsnormalen zu den ersten Quantisierungsnormalen in der Nähe des Prädiktionswerts, wobei sich die zweiten Quantisierungsnormale durch eine zweite Quantisierungsstufe unterscheiden, die kleiner als die erste Quantisierungsstufe ist; und Umkehrquantisierungsmitteln (302) zum Durchführen einer Umkehrquantisierung des eingegebenen Pixelwerts unter Verwendung der Quantisierungsnormale von den Linear- und Nichtlinearquantisierungsnormal-Erzeugungsmitteln, um einen Regenerationswert zu erhalten.

11. Bilddecodiertorrichtung nach Anspruch 10, die weiterhin Verschiebewert-Erzeugungsmittel zum Erzeugen eines Verschiebewerts aus dem Prädiktionswert aufweisen, **dadurch gekennzeichnet, dass** die Nichtlinearquantisierungsnormal-Erzeugungsmittel bis zu M Normale in der Nähe eines Verschiebe-Prädiktionswerts addieren, der durch Subtrahieren des Verschiebewerts von dem Prädiktionswert erhalten wird, und den Verschiebewert zu dem Regenerationswert addieren, um einen Pixelwert zu erhalten, und ihn dann ausgeben.
12. Bilddecodiertorrichtung nach Anspruch 11, die weiterhin Verschiebewert-Erzeugungsmittel zum Erzeugen eines Verschiebewerts aus dem Prädiktionswert aufweist, **dadurch gekennzeichnet, dass** die Prädiktionswert-Linearquantisierungswert-Erzeugungsmittel, die einen Verschiebe-Prädiktionswert, der durch Subtrahieren des Verschiebewerts von dem Prädiktionswert erhalten wird, durch 2^k di-

vidieren, wobei k une Ganzzahl ist, um einen Linearquantisierungswert des Prädiktionswerts zu erzeugen, und den Verschiebewert zu dem Regenerationswert addieren, um einen Pixelwert zu erhalten, und ihn dann ausgeben.

13. Bilddecodiervorrichtung nach Anspruch 10, 11 oder 12, **dadurch gekennzeichnet, dass** die Linearquantisierungsnormale-Erzeugungsmittel Offset-Wert-Addiermittel haben, die einen Offset-Wert mittels eines Rests nach dem Dividieren des Prädiktionswerts durch 2^k ermitteln, wobei k eine Ganzzahl ist und der Offset-Wert zu dem Linearquantisierungsnormale der Linearquantisierungsnormale-Erzeugungsmittel addiert wird.

14. Bilddecodiervorrichtung nach Anspruch 10, 11 oder 12, **dadurch gekennzeichnet, dass** ein spezielles n -Bit-Muster als ein Fehlercode angesehen wird, der nicht bei einer normalen Codierung verwendet wird, und der Prädiktionswert als der Regenerationswert angesehen wird, wenn ein Muster des eingegebenen Quantisierungswerts mit einem Muster des Fehlercodes übereinstimmt.

15. Bilddecodiervorrichtung nach Anspruch 14, **dadurch gekennzeichnet, dass** in dem Fall, dass die Gefahr besteht, dass der eingegebene Quantisierungswert, der übertragen werden soll, einen Fehler enthält, der eingegebene Quantisierungswert durch den Fehlercode ersetzt wird.

Revendications

1. Appareil de codage d'image qui code une valeur de pixels d'entrée avec une plage dynamique prédéterminée pour obtenir une valeur de quantification à N bits et la transmettre, comprenant :

un moyen de génération de valeur prédictive (106) pour générer une valeur prédictive de la valeur de pixels d'entrée à partir de pixels à proximité des pixels d'entrée ;

un moyen de génération de niveaux de quantification linéaires (102) pour subdiviser linéairement ladite plage dynamique prédéterminée en utilisant $2^N - M$ premiers niveaux de quantification, où M est une limite supérieure entière prédéterminée, lesdits premiers niveaux de quantification différant d'un premier pas de quantification ;

un moyen de génération de niveaux de quantification non linéaires (103) pour ajouter jusqu'à M deuxièmes niveaux de quantification auxdits premiers niveaux de quantification à proximité de ladite valeur prédictive, lesdits deuxièmes ni-

veaux de quantification différant d'un deuxième pas de quantification plus petit que ledit premier pas de quantification ; et
un moyen de quantification (104) pour quantifier la valeur de pixels d'entrée en utilisant les niveaux de quantification provenant desdits moyens de génération de niveaux linéaires et non linéaires.

2. Appareil de codage d'image selon la revendication 1 comprenant en outre un moyen pour générer une valeur de décalage par rapport à une valeur prédictive générée par ledit moyen de génération de valeur prédictive, dans lequel :

ledit moyen de génération de niveaux de quantification non linéaires ajoute lesdits niveaux de quantification à proximité d'une valeur prédictive de décalage qui est obtenue en soustrayant ladite valeur de décalage de ladite valeur prédictive ; et

ledit moyen de quantification quantifie une valeur d'entrée de décalage qui est obtenue en soustrayant ladite valeur de décalage d'une valeur de pixels d'entrée.

3. Appareil de codage d'image selon la revendication 1 comprenant en outre un moyen de restriction de valeur d'entrée qui examine si la grandeur de ladite valeur de pixels d'entrée est dans une plage spécifiée et, lorsqu'elle est dans la plage, délivre en sortie ladite valeur de pixels d'entrée vers ledit moyen de génération de niveaux de quantification linéaires, et lorsqu'elle est hors de la plage, ne délivre pas en sortie ladite valeur de pixels d'entrée, mais délivre en sortie une valeur de quantification restreinte spécifiée vers ledit moyen de génération de niveaux de quantification non linéaires.

4. Appareil de codage d'image selon la revendication 1 dans lequel ledit moyen de génération de niveaux de quantification linéaires a un moyen d'ajout de valeur de décalage qui détermine une valeur de décalage par un reste après division de ladite valeur prédictive par 2^k , k étant un entier, ladite valeur de décalage étant ajoutée au niveau de quantification linéaire dudit moyen de génération de niveaux de quantification linéaires.

5. Appareil de codage d'image selon la revendication 1, 3 ou 4 comprenant en outre un moyen de restriction de valeur d'entrée pour restreindre la grandeur de ladite valeur de pixels d'entrée pour délivrer en sortie une valeur d'entrée restreinte.

6. Appareil de codage d'image selon la revendication 2 comprenant en outre un moyen de restriction de valeur d'entrée de décalage pour restreindre la gran-

deur de ladite valeur d'entrée de décalage pour délivrer en sortie une valeur d'entrée de décalage restreinte.

7. Appareil de codage d'image selon la revendication 1, 2 ou 3 dans lequel ledit moyen de quantification a un moyen de restriction de valeur de quantification pour restreindre la grandeur de la valeur de quantification générée. 5
8. Appareil de codage d'image selon la revendication 1, 2 ou 3 dans lequel ledit moyen de quantification génère une valeur de quantification de telle sorte que lorsqu'une valeur de pixels d'entrée est minimum, sa valeur de quantification correspondante est minimum, et, lors de l'augmentation de la valeur de pixels d'entrée, sa valeur de quantification correspondante augmente. 10 15
9. Appareil de codage d'image selon la revendication 5, 6, 7 ou 8 dans lequel ledit moyen de quantification définit un motif spécifique à n bits comme un code d'erreur, ledit motif n'étant pas utilisé pour une valeur de quantification de sortie. 20 25
10. Appareil de décodage d'image qui décode une valeur de quantification à N bits pour obtenir une valeur régénérative avec une plage dynamique prédéterminée, comprenant : 30
 - un moyen de génération de valeur prédictive (106) pour générer une valeur prédictive d'une valeur de quantification d'entrée à partir de pixels à proximité de la valeur de quantification d'entrée ;
 - un moyen de génération de niveaux de quantification linéaires (102) pour subdiviser linéairement ladite plage dynamique prédéterminée en utilisant $2^N - M$ premiers niveaux de quantification, où M est une limite supérieure entière prédéterminée, lesdits premiers niveaux de quantification différant d'un premier pas de quantification ;
 - un moyen de génération de niveaux de quantification non linéaires (103) pour ajouter jusqu'à M deuxièmes niveaux de quantification auxdits premiers niveaux de quantification à proximité de ladite valeur prédictive, lesdits deuxièmes niveaux de quantification différant d'un deuxième pas de quantification plus petit que ledit premier pas de quantification ; et
 - un moyen de quantification inverse (302) pour effectuer une quantification inverse de la valeur de pixels d'entrée en utilisant les niveaux de quantification provenant desdits moyens de génération de niveaux linéaires et non linéaires pour obtenir une valeur régénérative. 45 50 55

11. Appareil de décodage d'image selon la revendication 10 comprenant en outre un moyen de génération de valeur de décalage pour générer une valeur de décalage à partir de ladite valeur prédictive dans lequel :

ledit moyen de génération de niveaux de quantification non linéaires ajoute jusqu'à M niveaux à proximité d'une valeur prédictive de décalage qui est obtenue en soustrayant ladite valeur de décalage de ladite valeur prédictive, et ajoute ladite valeur de décalage à ladite valeur régénérative pour obtenir une valeur de pixels et ensuite la délivre en sortie.

12. Appareil de décodage d'image selon la revendication 11 comprenant en outre un moyen de génération de valeur de décalage pour générer une valeur de décalage à partir de ladite valeur prédictive dans lequel :

ledit moyen de génération de valeur de quantification linéaire de valeur prédictive qui divise une valeur prédictive de décalage qui est obtenue en soustrayant ladite valeur de décalage de ladite valeur prédictive, par 2^k , k étant un entier, pour générer une valeur de quantification linéaire de valeur prédictive, et ajoute ladite valeur de décalage à ladite valeur régénérative pour obtenir une valeur de pixels et ensuite la délivre en sortie.

13. Appareil de décodage d'image selon la revendication 10, 11 ou 12 dans lequel ledit moyen de génération de niveaux de quantification linéaires a un moyen d'ajout de valeur de décalage qui détermine une valeur de décalage par un reste après division de ladite valeur prédictive par 2^k , k étant un entier, ladite valeur de décalage étant ajoutée au niveau de quantification linéaire dudit moyen de génération de niveaux de quantification linéaires. 35 40

14. Appareil de décodage d'image selon la revendication 10, 11 ou 12 dans lequel un motif spécifique à n bits est considéré comme un code d'erreur qui n'est pas utilisé dans un codage normal, et ladite valeur prédictive est considérée comme ladite valeur régénérative lorsqu'un motif de ladite valeur de quantification d'entrée est conforme à un motif dudit code d'erreur. 45 50

15. Appareil de décodage d'image selon la revendication 14 dans lequel lorsque la valeur de quantification d'entrée devant être transmise a une possibilité d'inclure une erreur, ladite valeur de quantification d'entrée est remplacée par ledit code d'erreur. 55

Fig.16

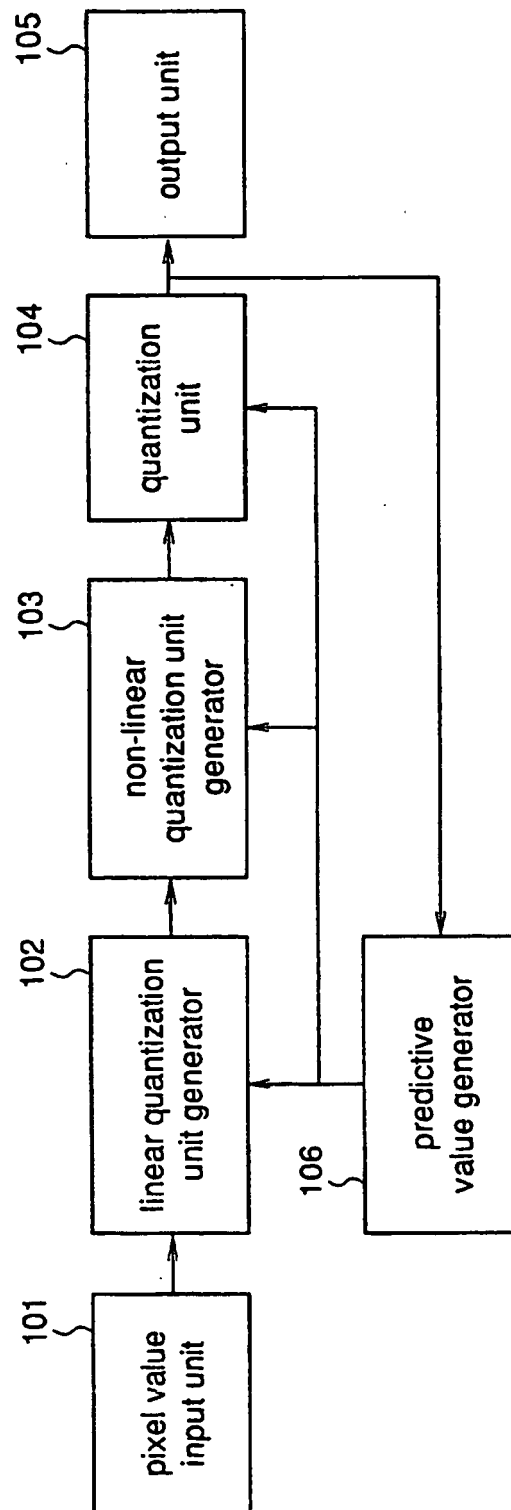


Fig.17 (a) linear quantization representative value

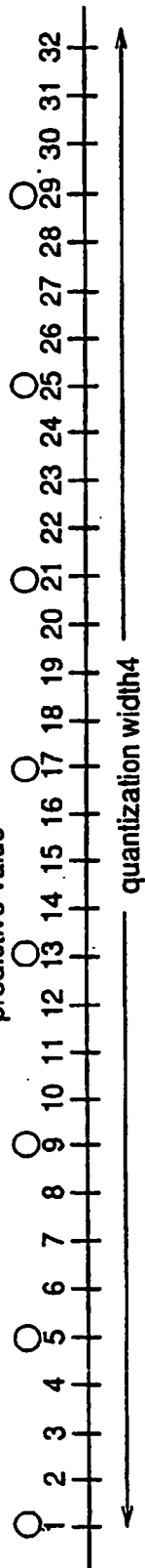


Fig.17 (b) addition of quantization value

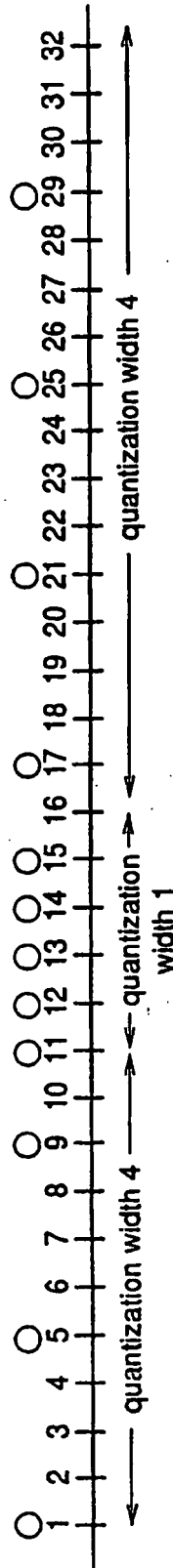


Fig.17 (c) allocation of quantization value

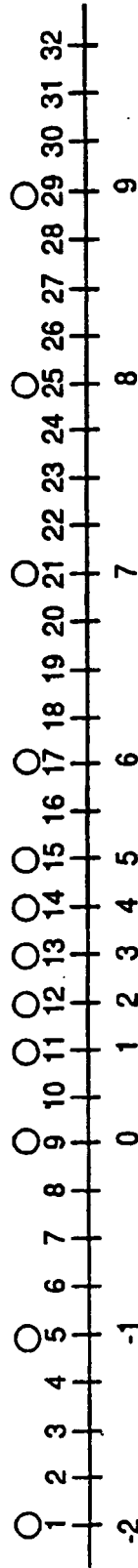


Fig.17 (d) quantization

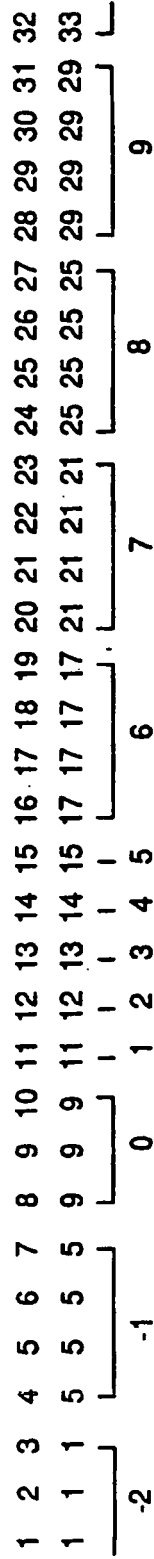


Fig.18

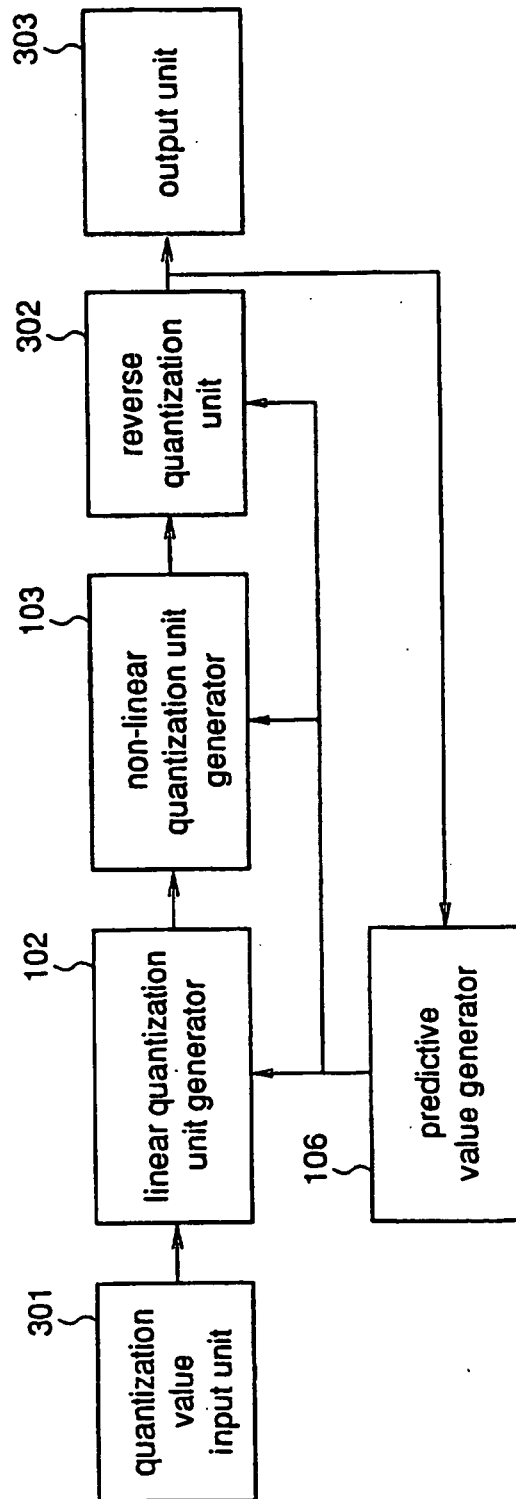


Fig.19

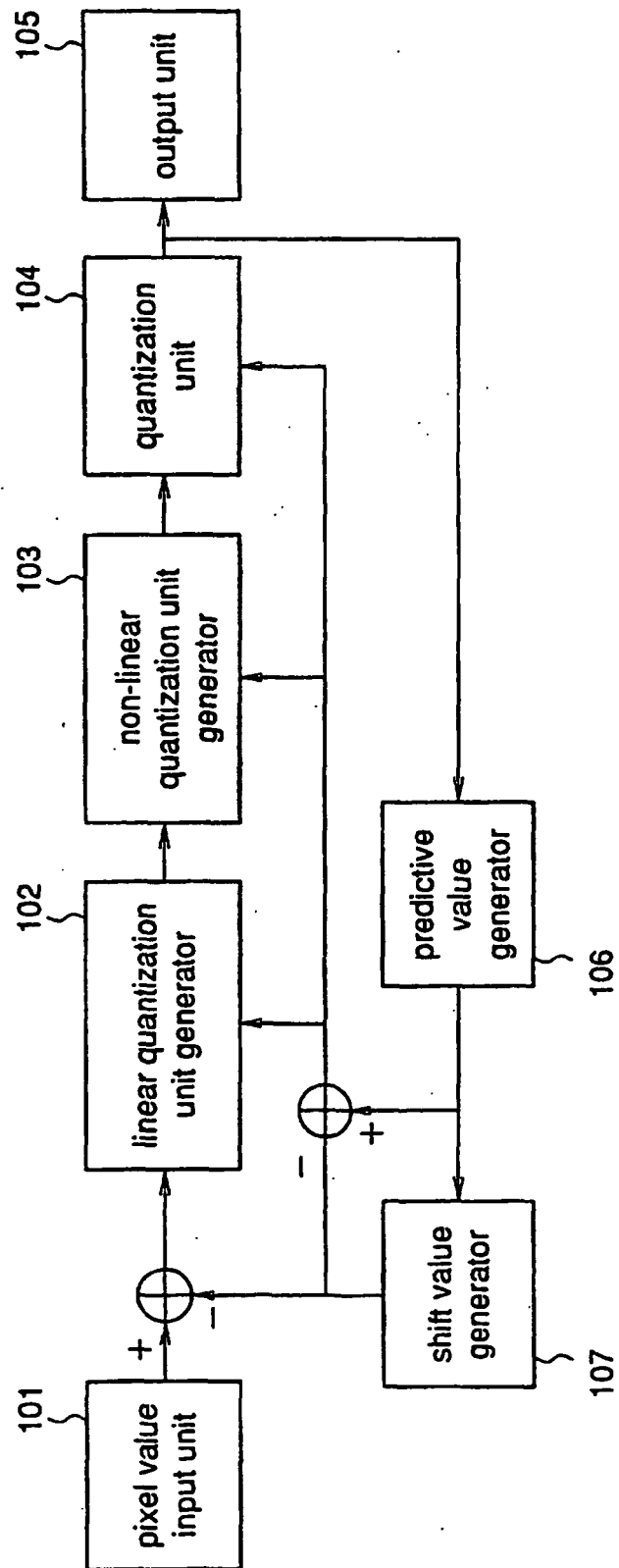


Fig.20 (a) linear quantization representative value

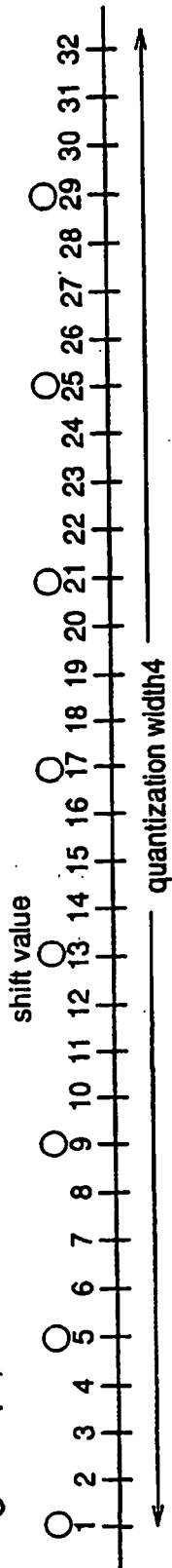


Fig.20 (b) addition of quantization value

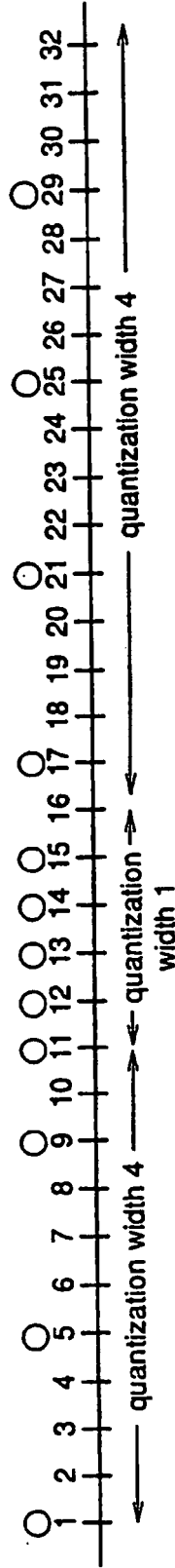


Fig.20 (c) allocation of quantization value

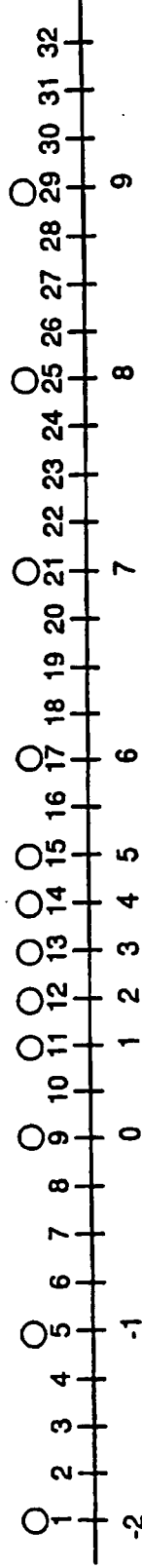


Fig.20 (d) quantization

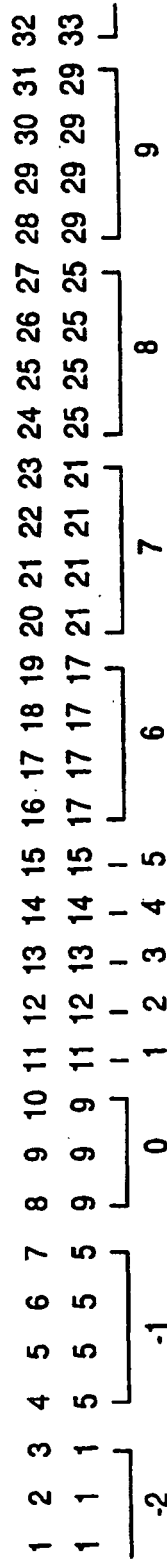


Fig.21

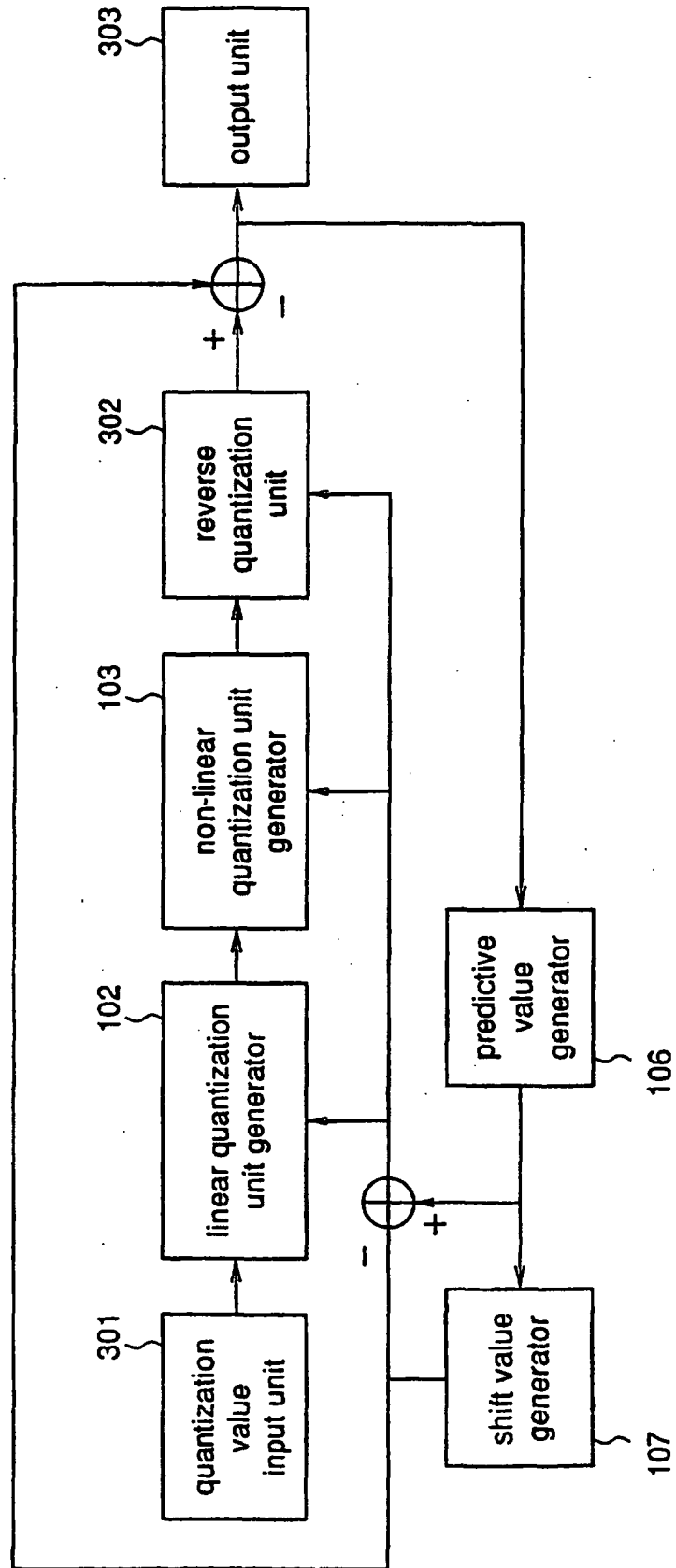
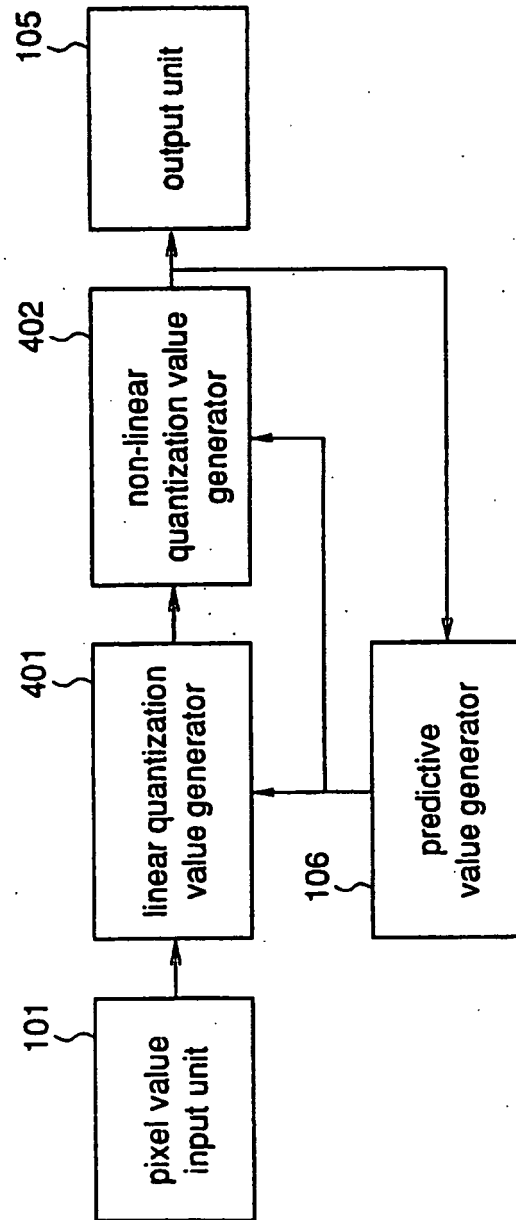


Fig.22



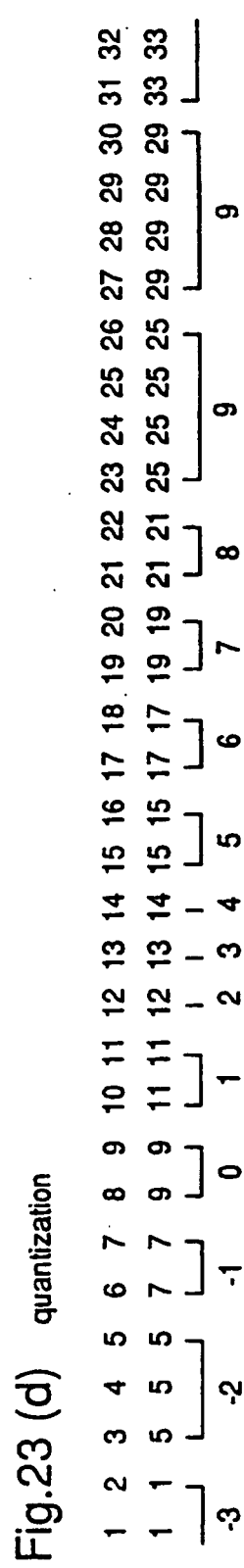
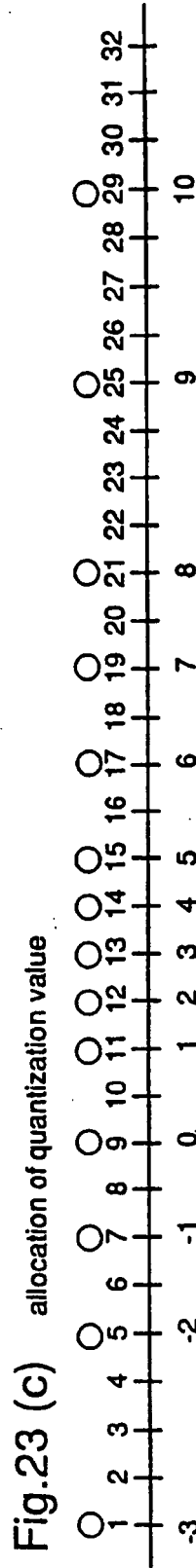
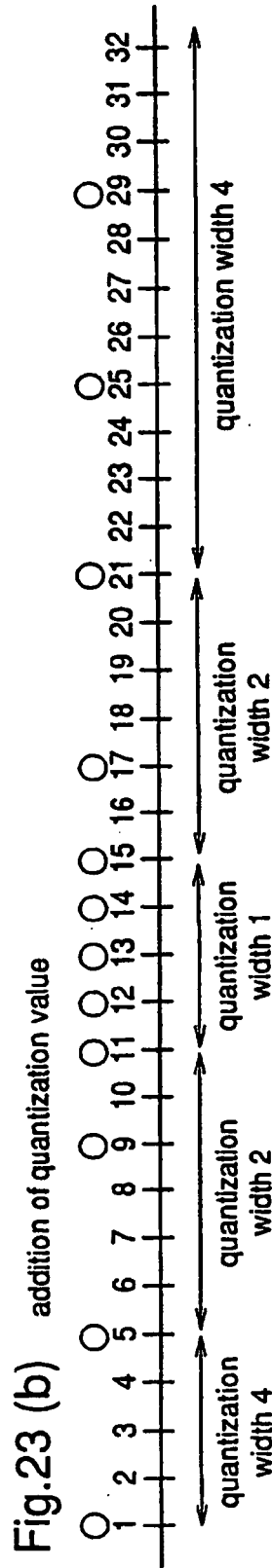
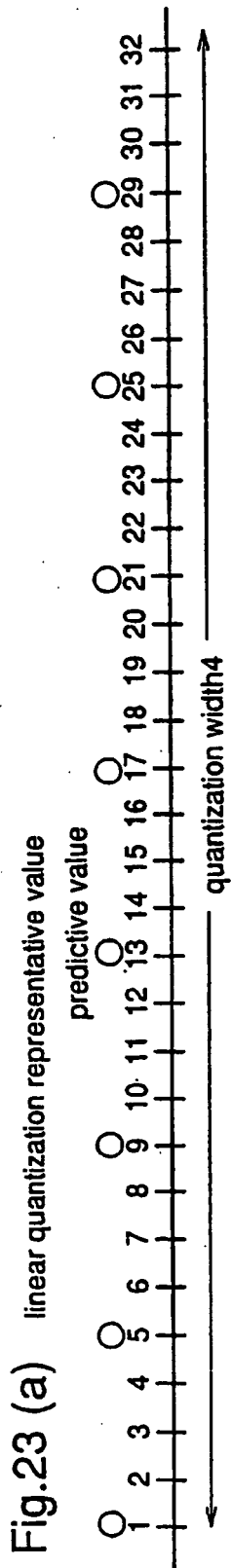


Fig.24

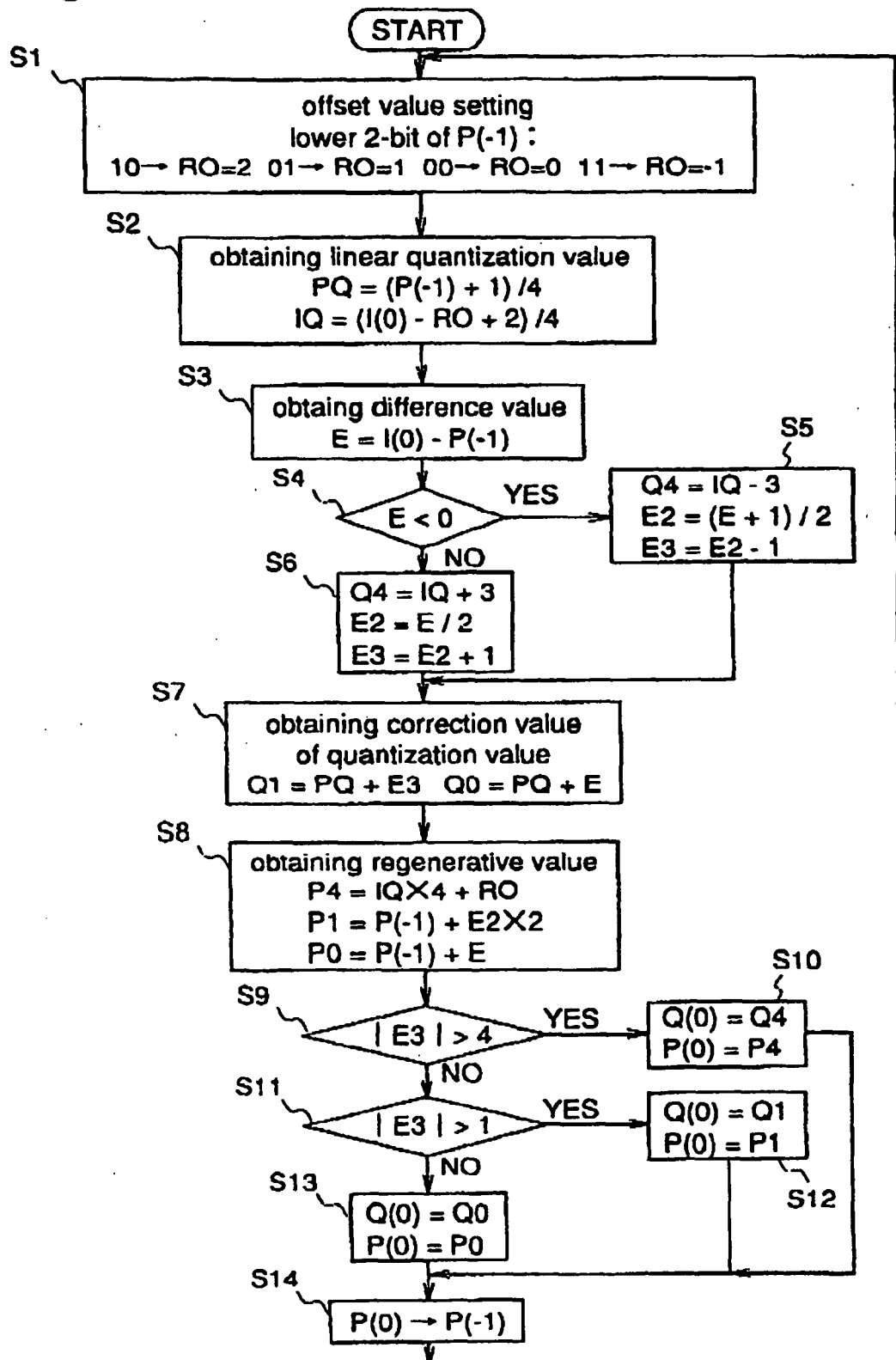


Fig.25

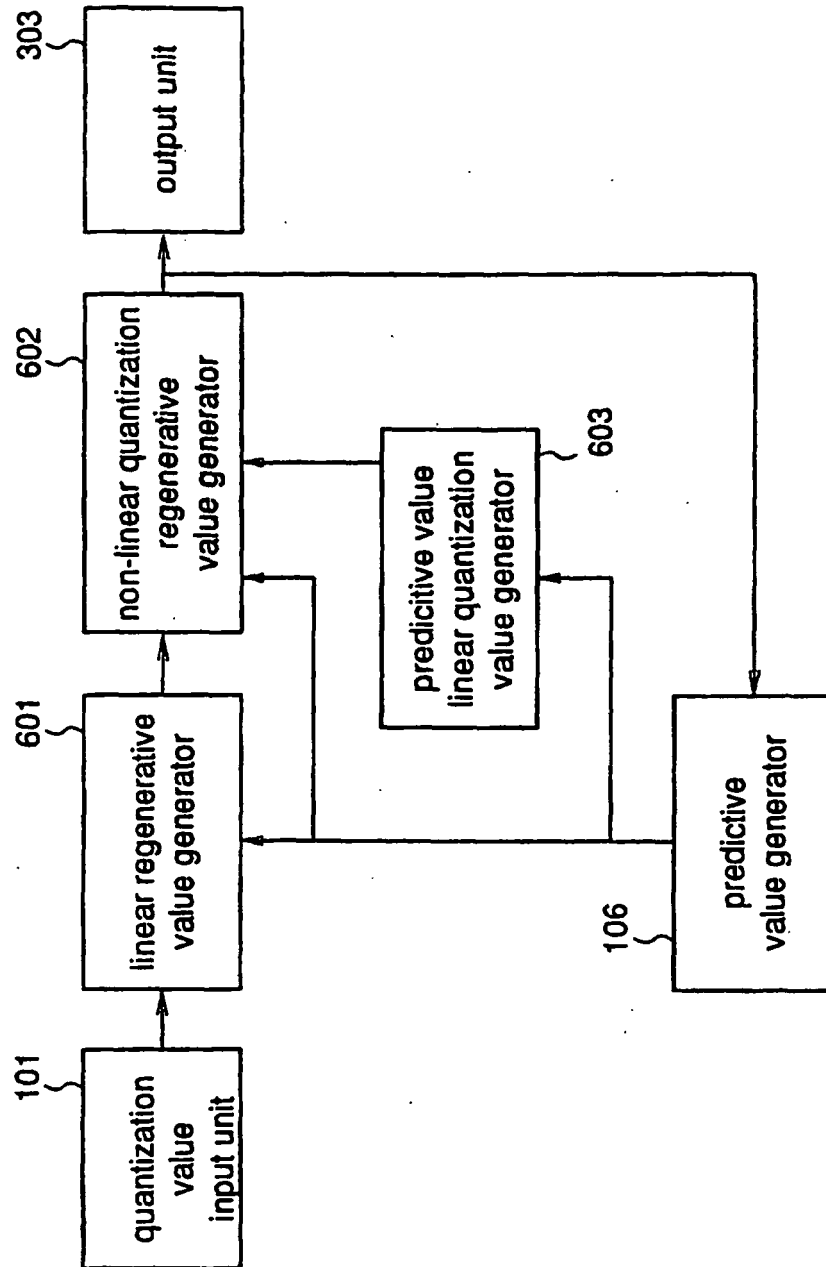


Fig.26

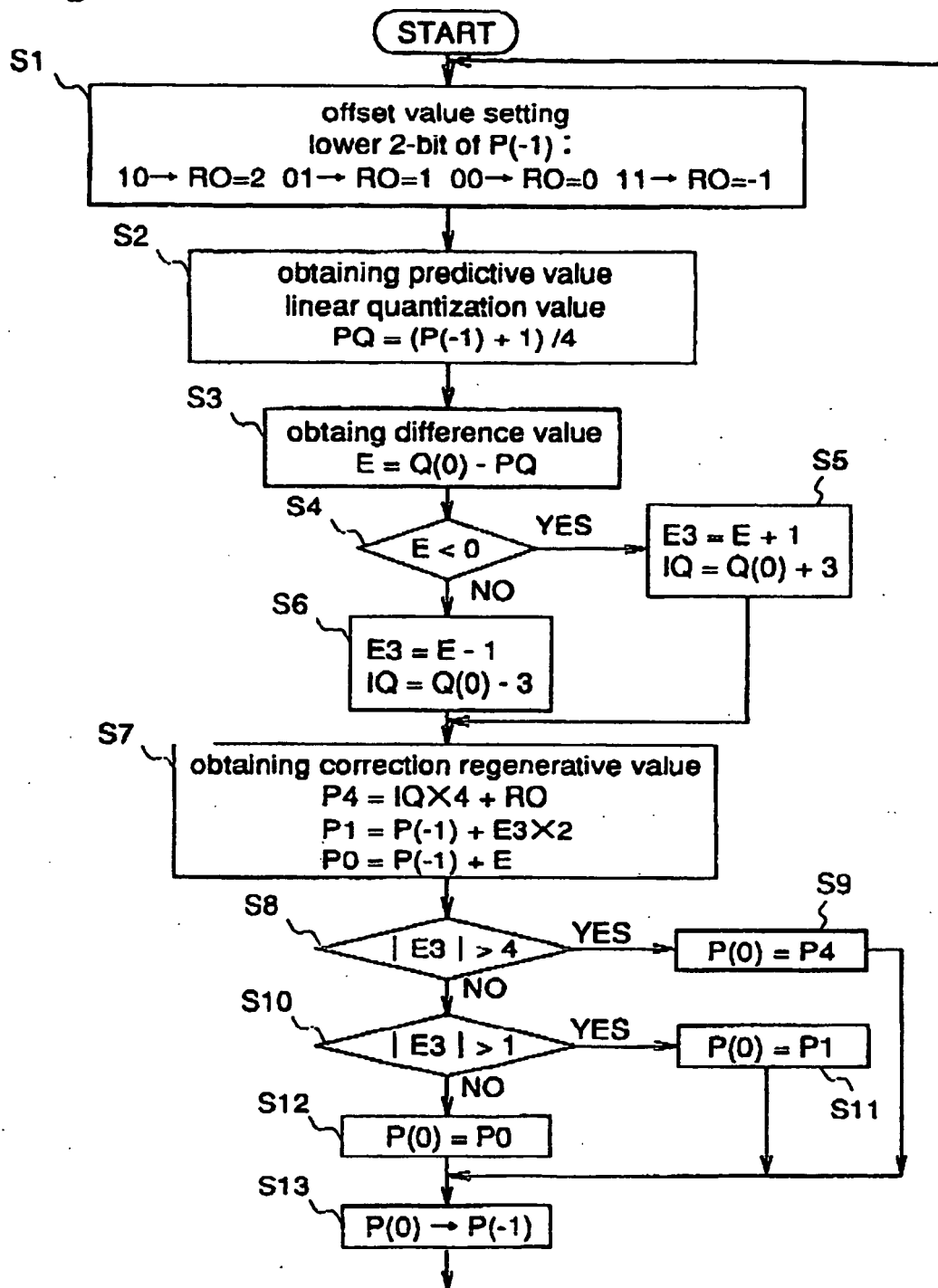


Fig.27

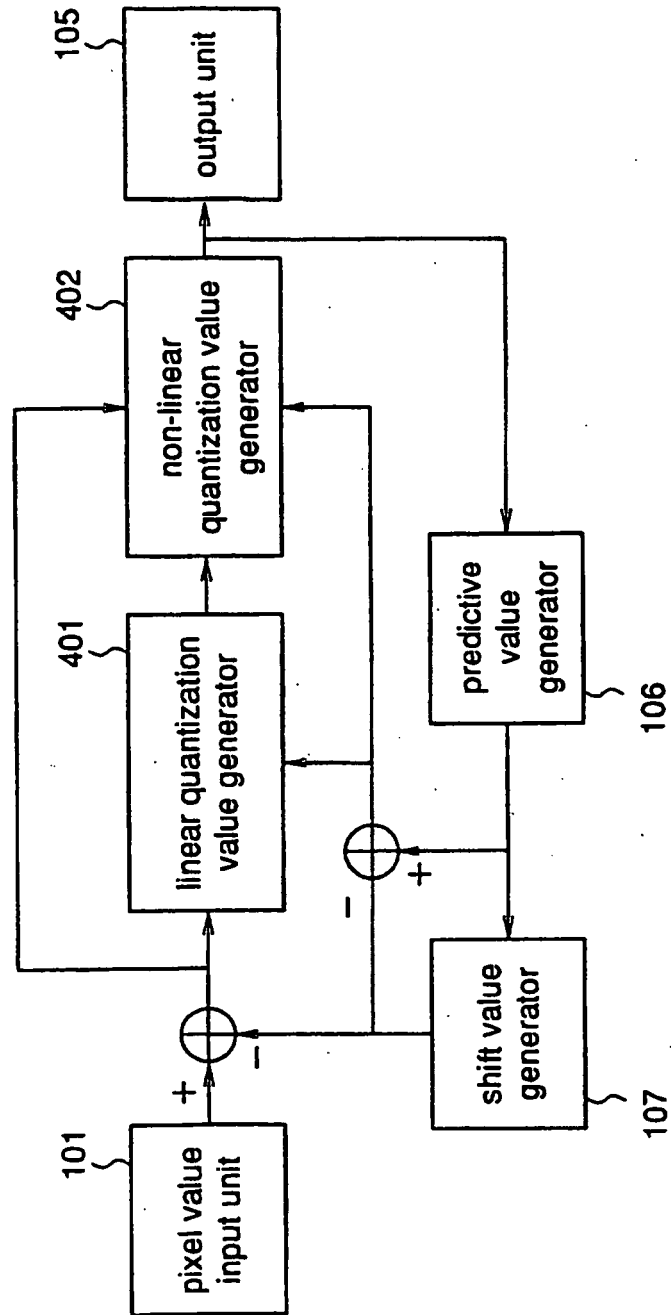


Fig.28

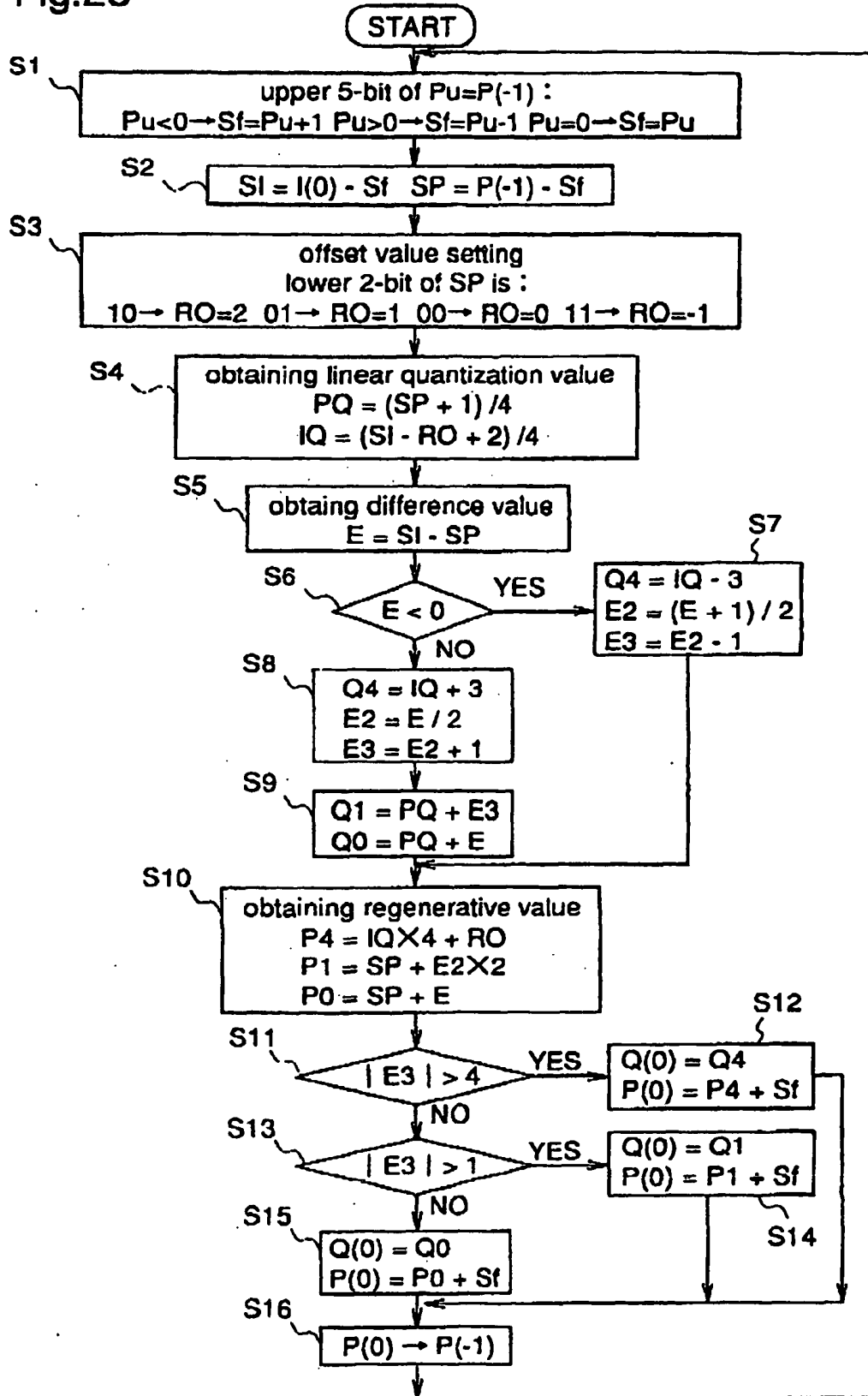


Fig.29

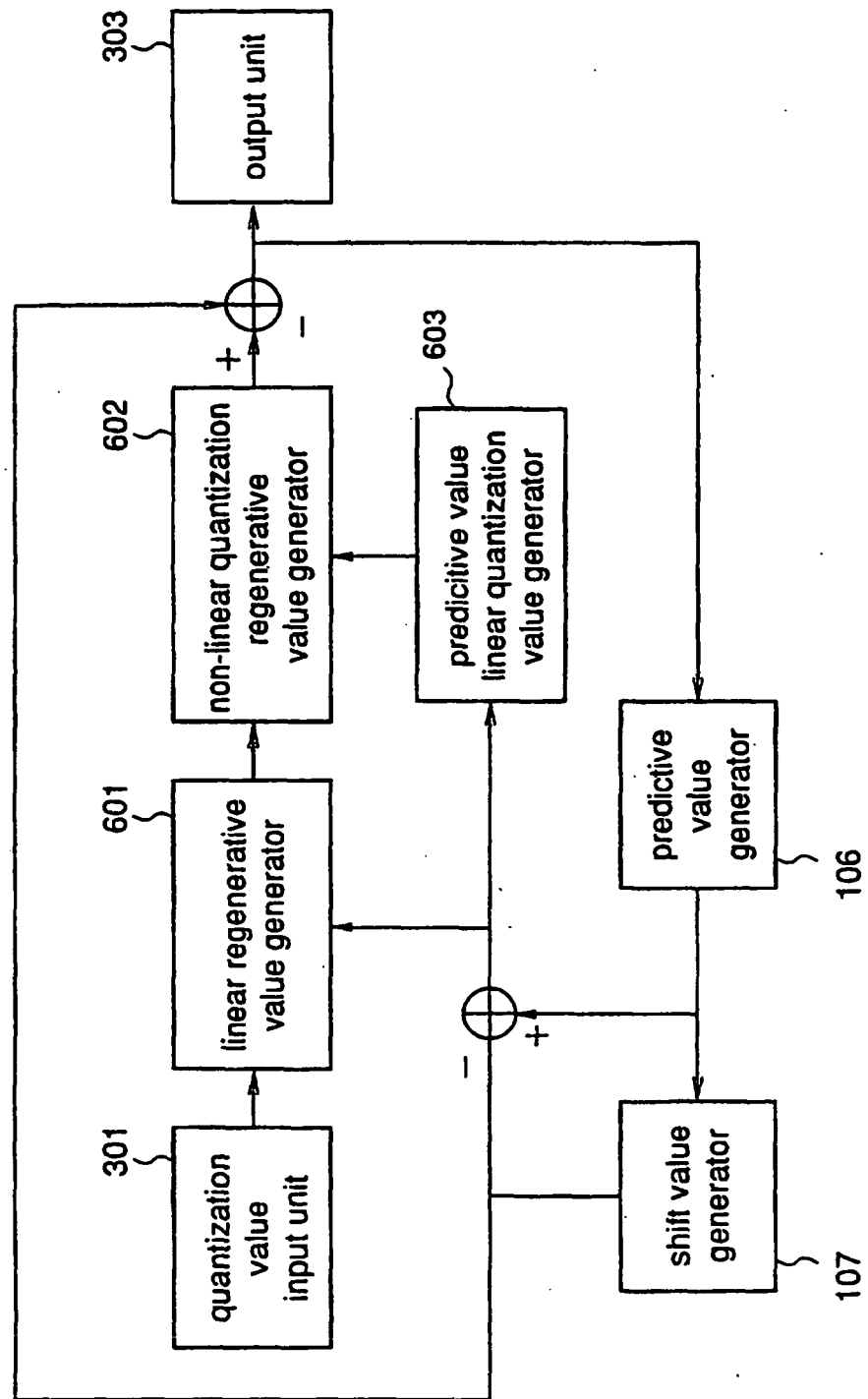


Fig.30

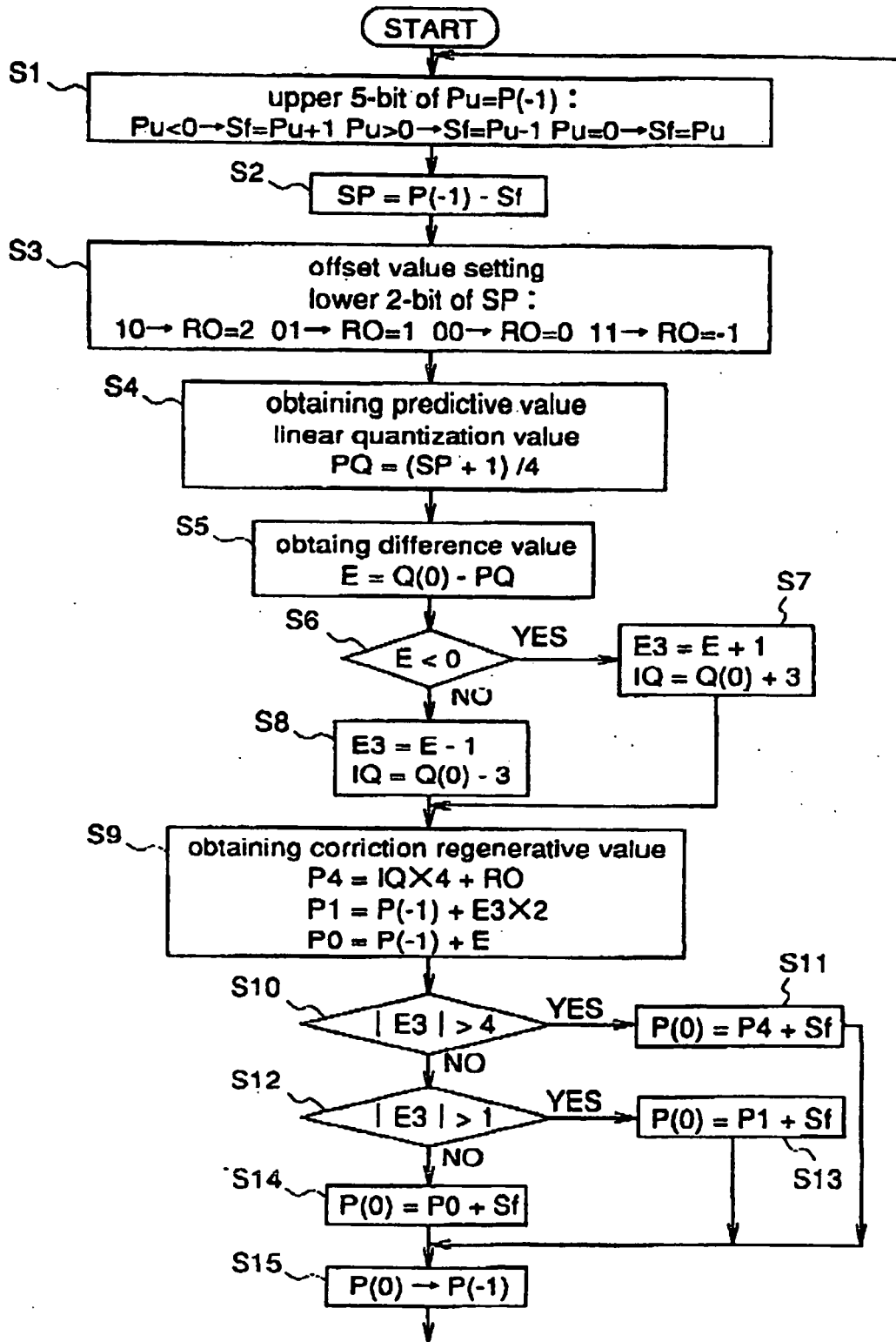


Fig.31

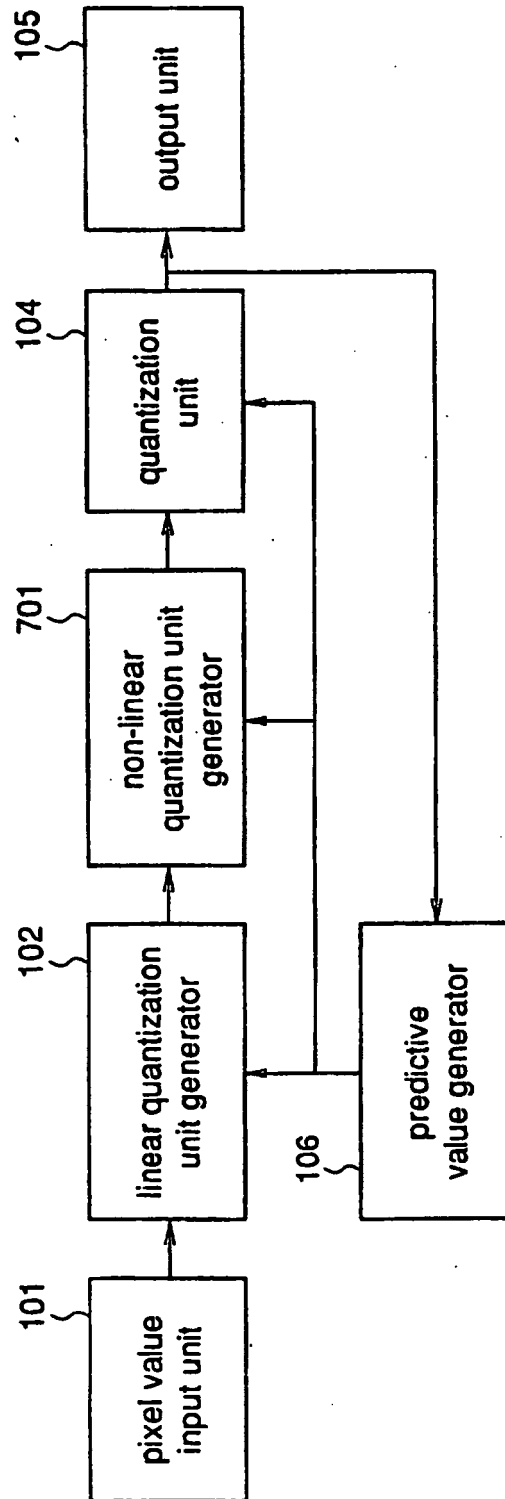


Fig.32 (a) linear quantization representative value

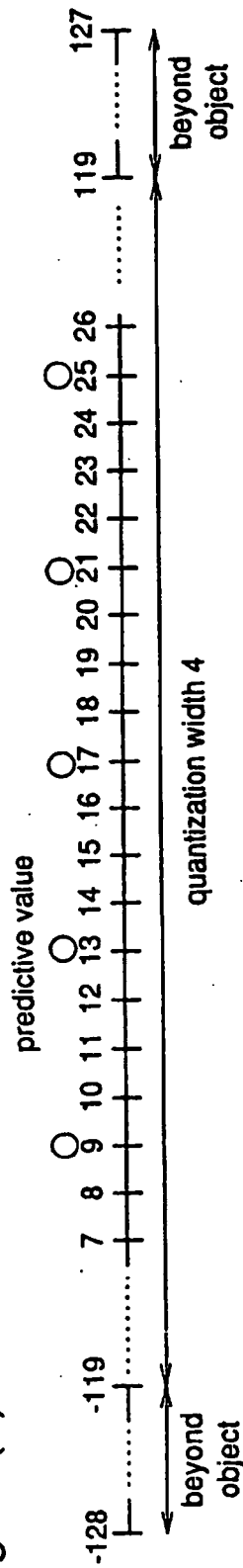


Fig.32 (b) addition of quantization representative value

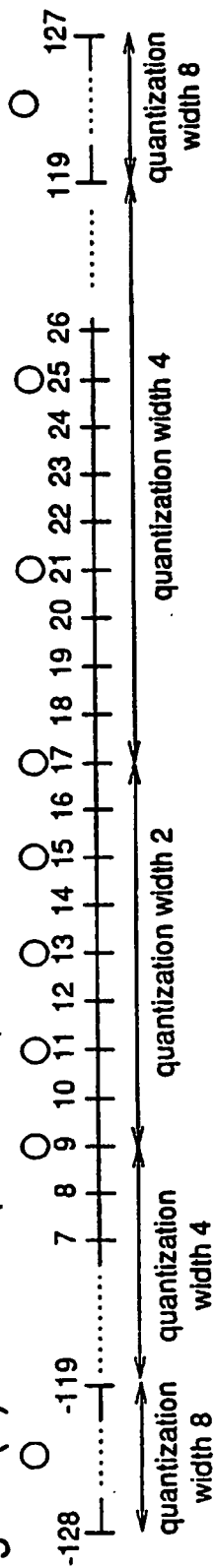


Fig.32 (c) allocation of quantization value

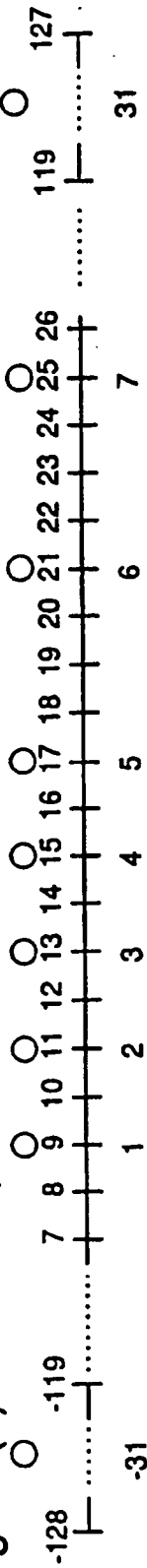


Fig.32 (d) quantization

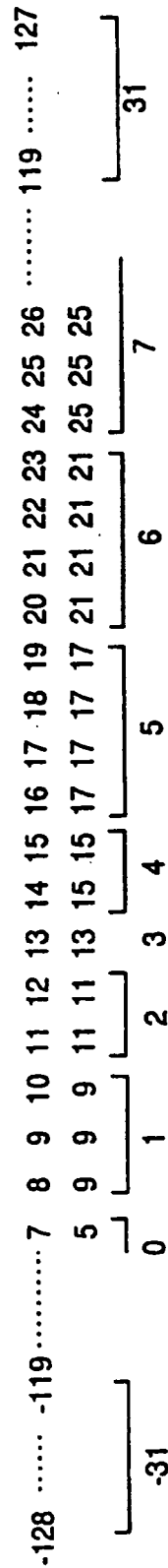


Fig.33

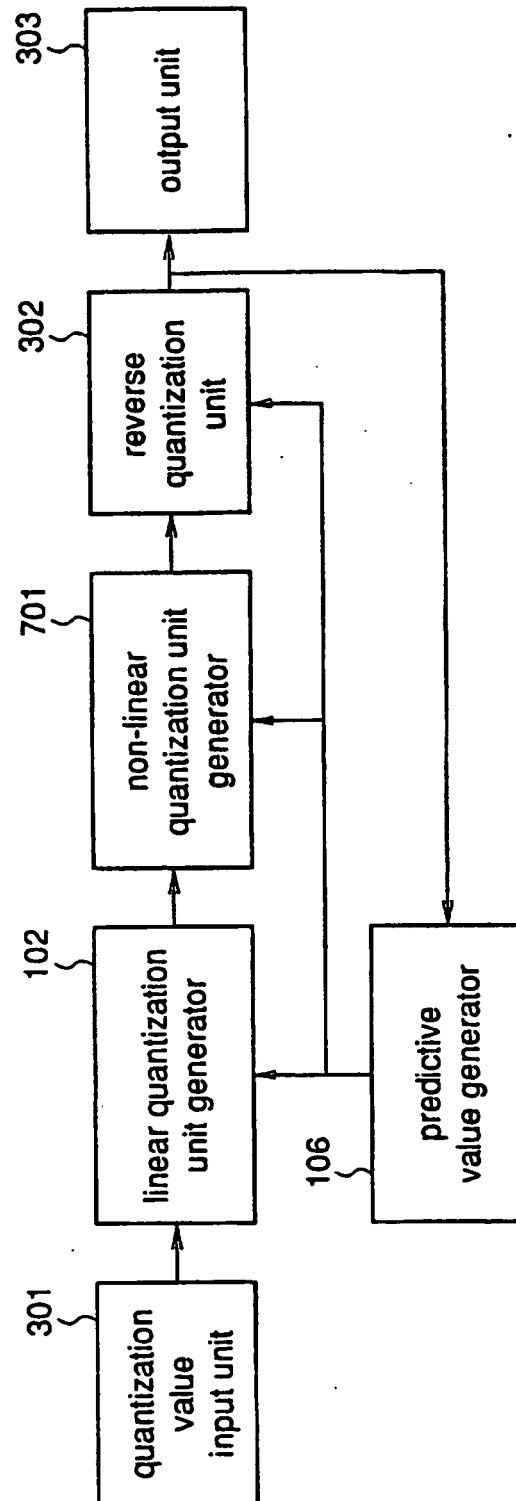


Fig.34

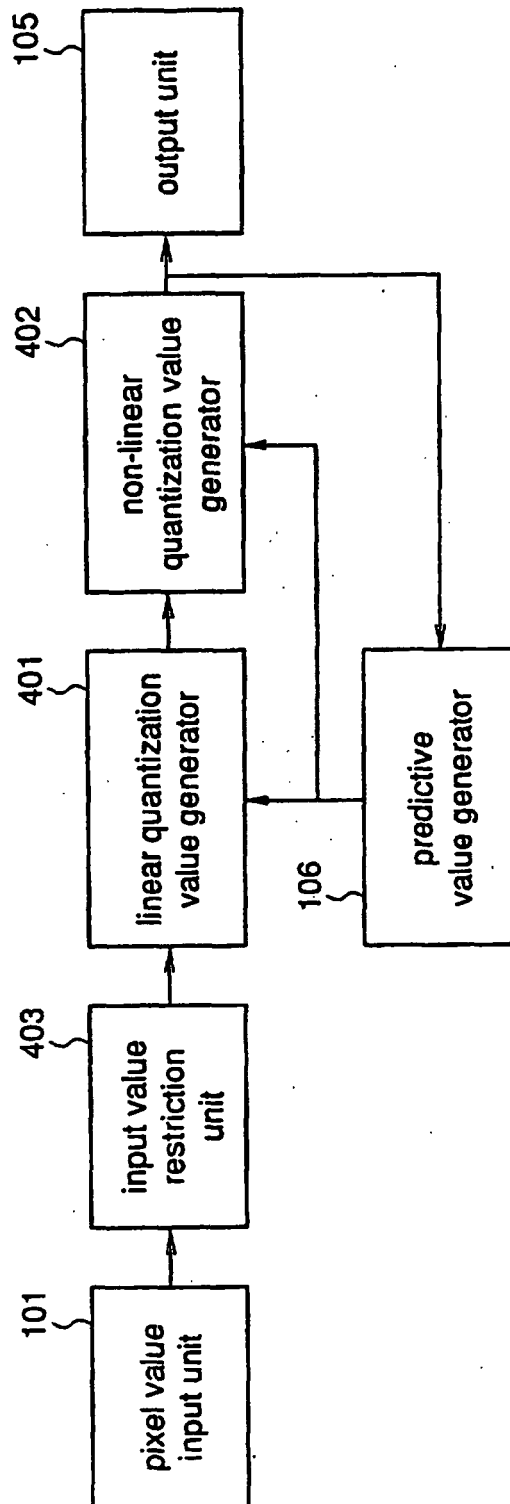


Fig.35

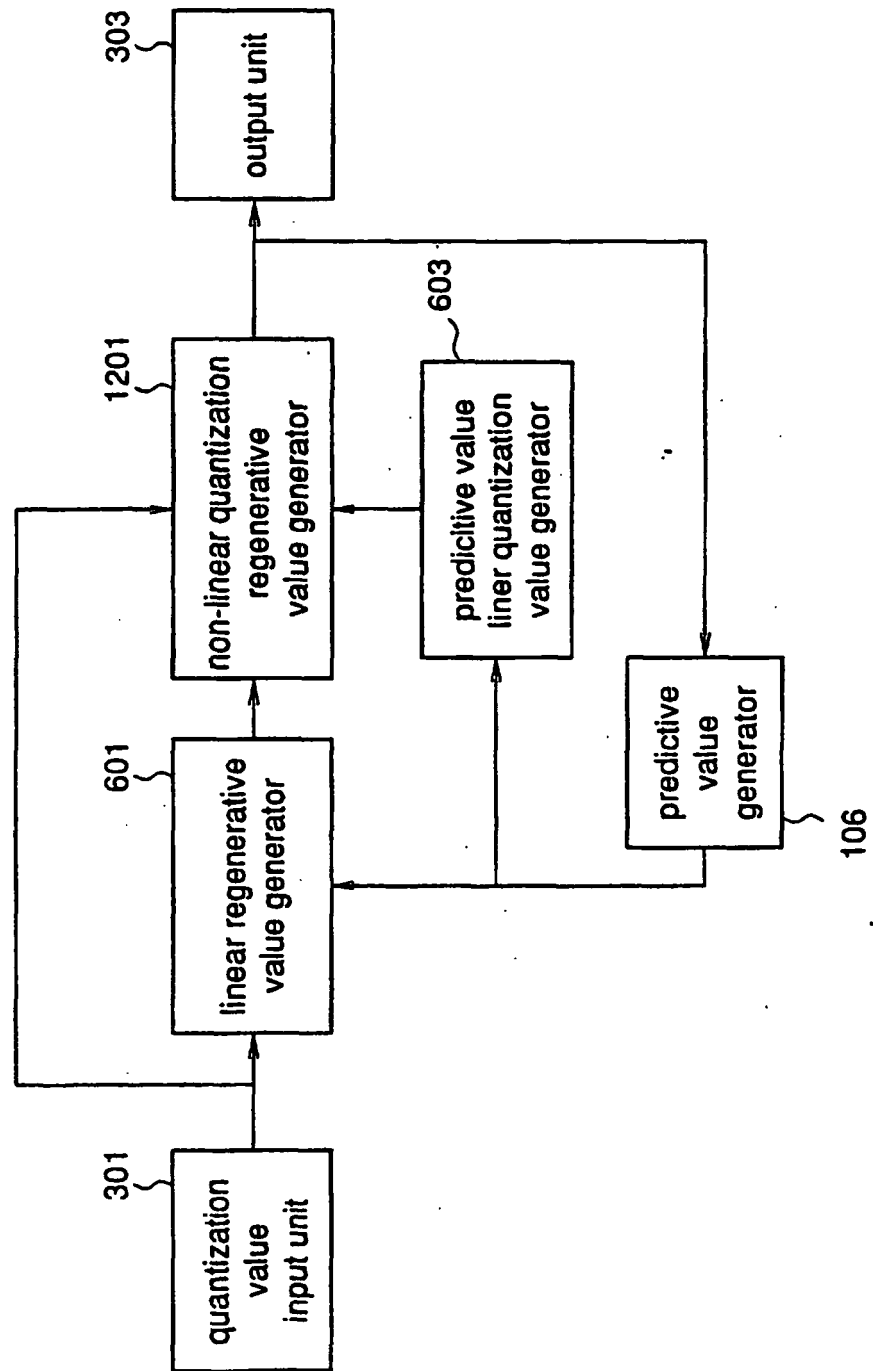


Fig.36 (a) coding

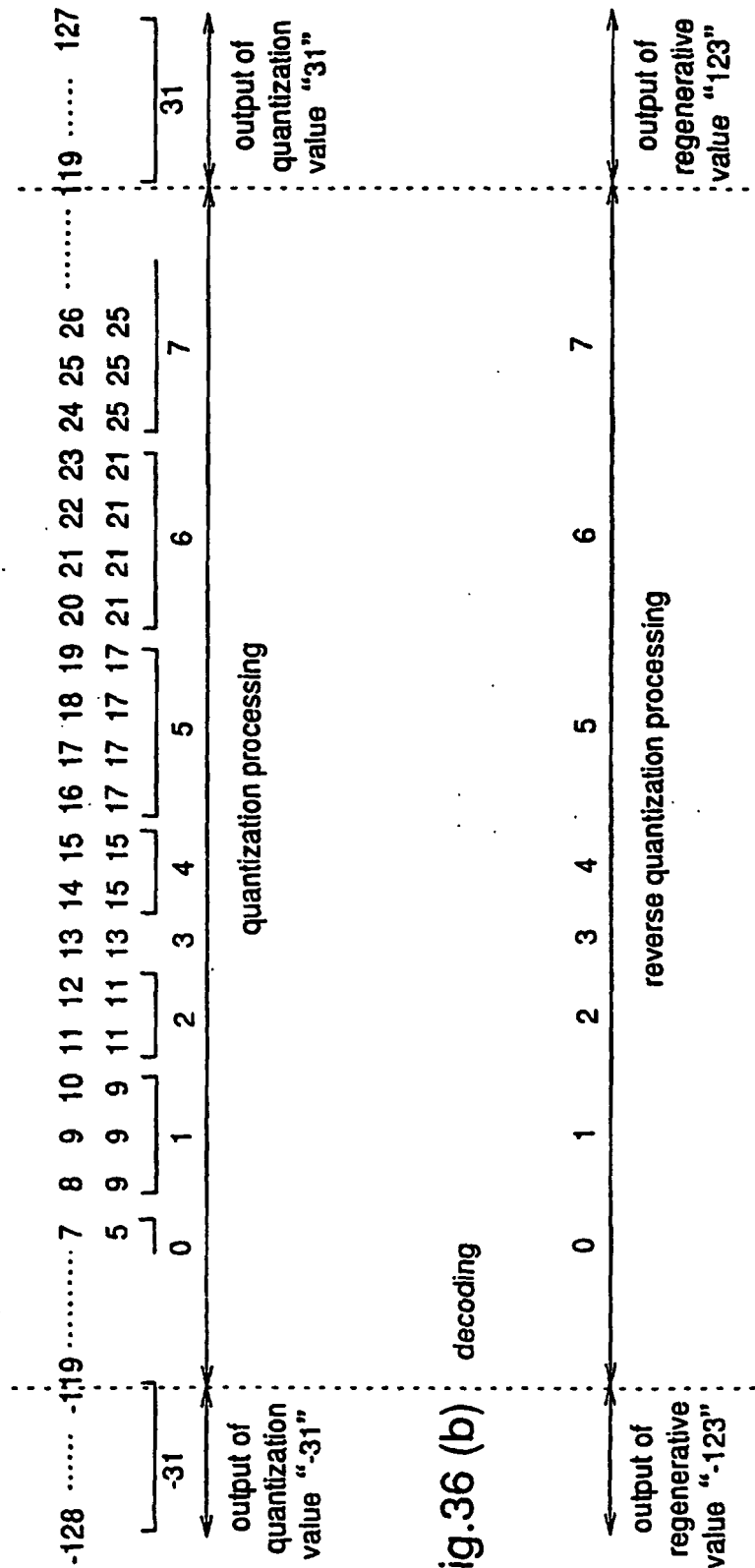


Fig.37

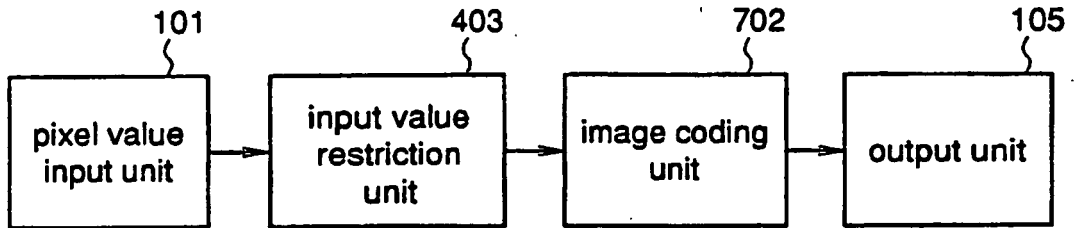


Fig.38

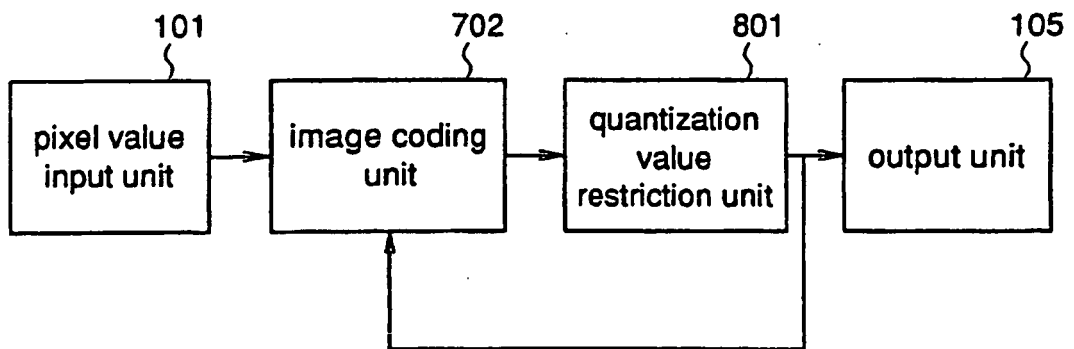


Fig.39

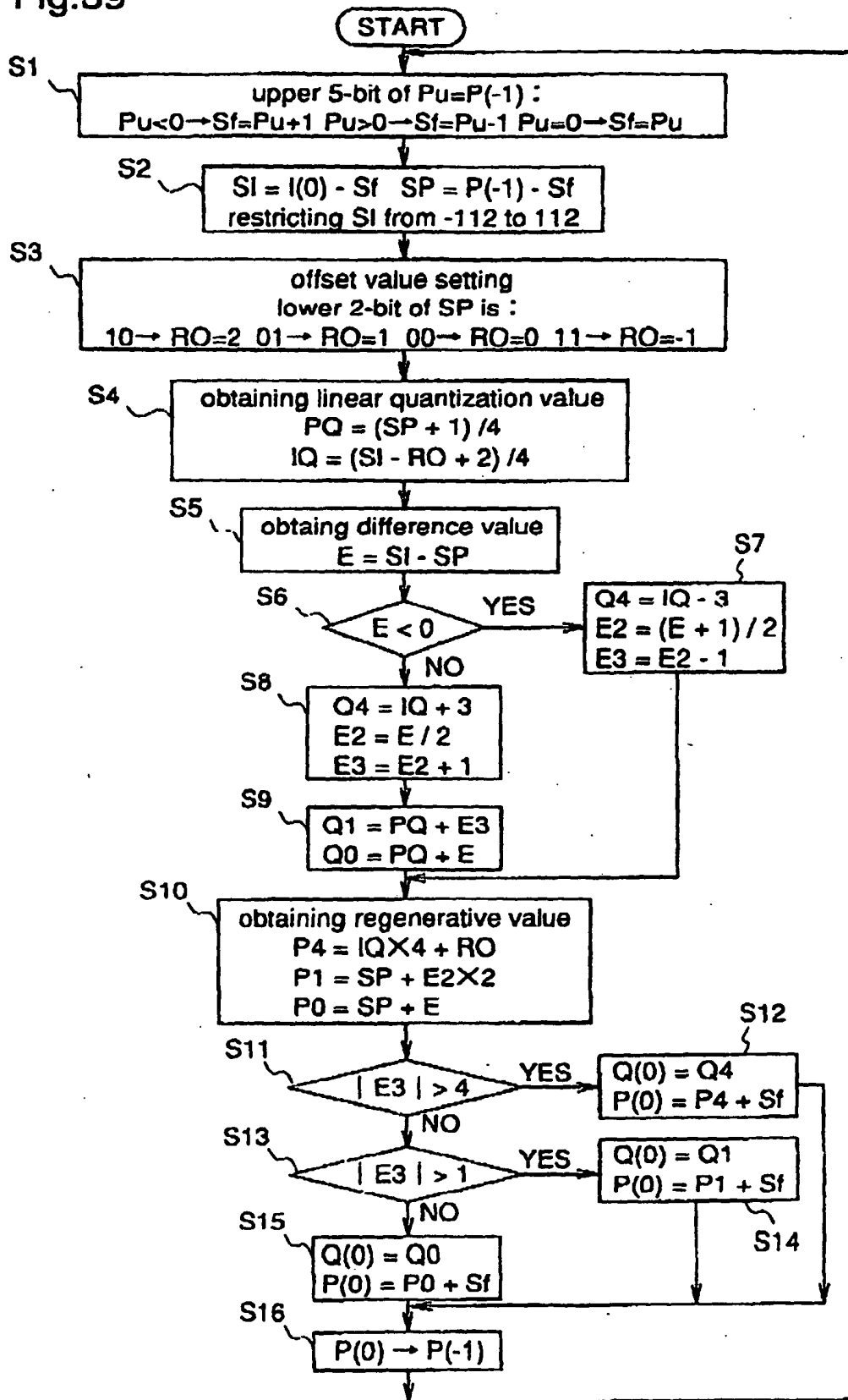


Fig.40

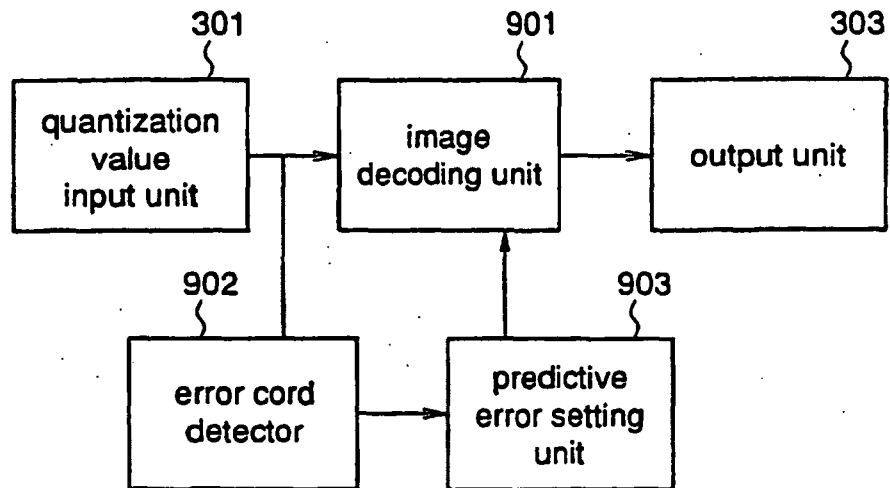


Fig.41

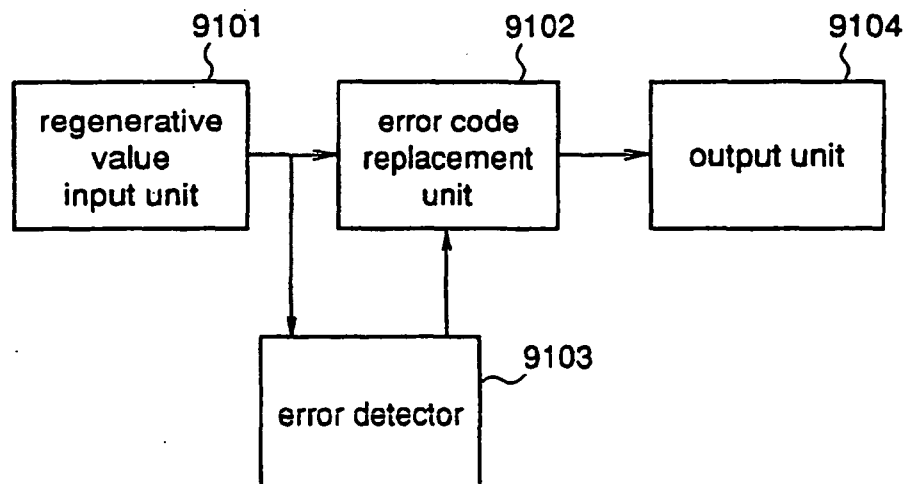


Fig.42

e : during quantization
d : during reverse quantization

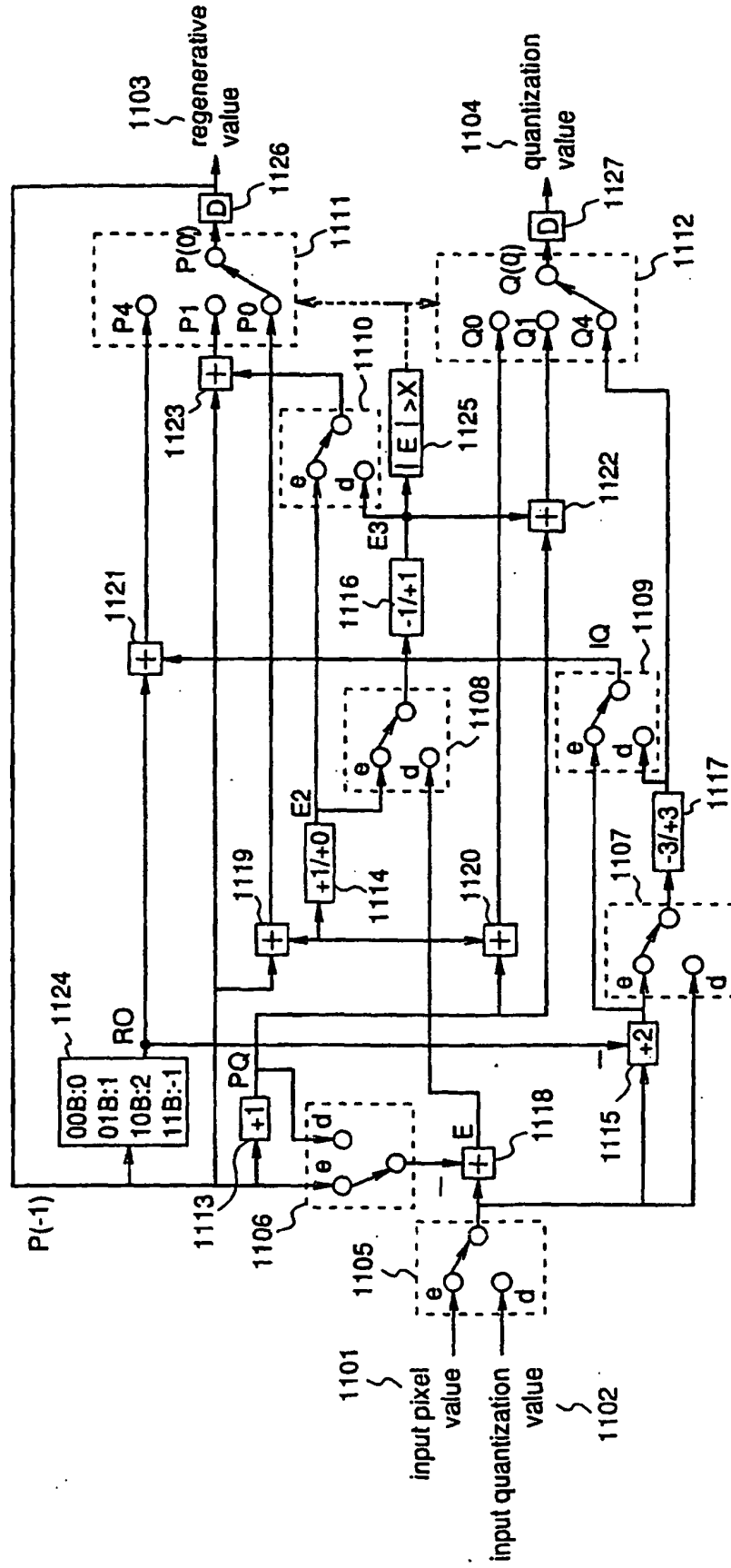
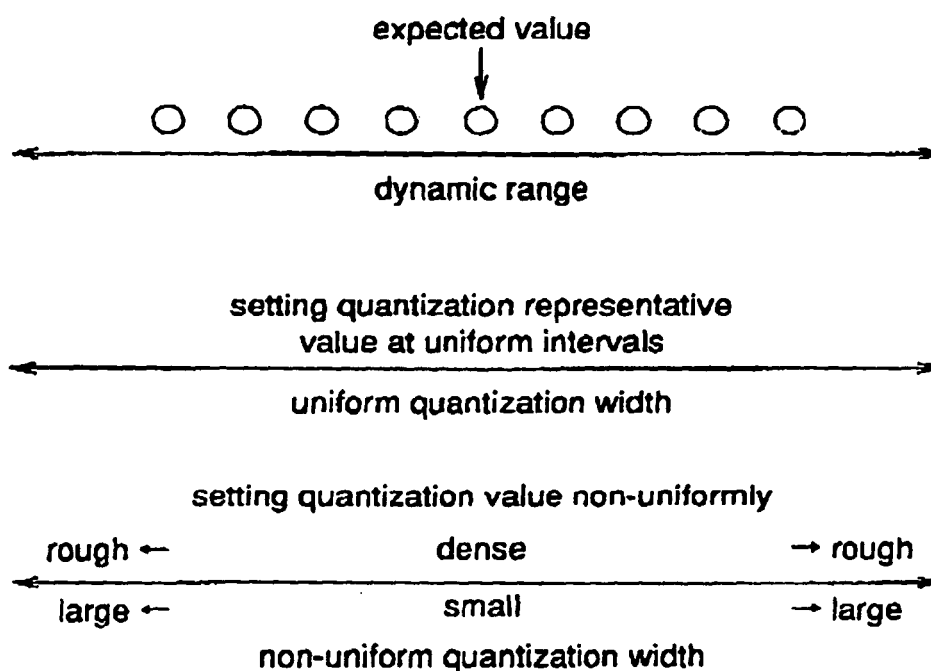


Fig.43 Prior Art



example : rounding processing of from 3-bit to 2-bit

linear quantization

input value	0	1	2	3	4	5	6	7
quantization representative value	0		2		4		6	
replacement with representative value	0	0	2	2	4	4	6	6

non-linear quantization

input value	0	1	2	3	4	5	6	7
quantization representative value		1		3	4		6	
or	0			3	4			7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 60160599 A [0012]